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Sustainable Economic Development
Challenges, Policies, and Reforms

Edited by
Vasilii Erokhin, Gao Tianming and Andrei Jean Vasile

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About the Editors

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Preface to ”Sustainable Economic Development: Challenges, Policies, and Reforms”

Today’s evolving economic landscape has increased the importance of sustainable development issues. Many parts of the world, territories, and societies are now changing at an unprecedented pace in ways that fundamentally affect the markets, people, environment, and biodiversity. Such changes are primarily driven by rapid social and economic developments, economic disparities between countries, the internationalization of production and value chains, industrialization, and globalization in the wider context. The previously established patterns are transforming and bringing new potential risks to the global economy, such as environmental pollution, climate change, economic disruptions, poverty, and food security. International initiatives, such as the United Nations (UN) Sustainable Development Goals, have been a powerful means to focus the attention, resources, and efforts of most of the countries in the world toward the fight against poverty, promotion of fair trade, support of heavily indebted countries, and the development of infrastructure of various kinds in underdeveloped regions. However, business interests are increasingly frequently interfering with such goals. The major challenge is converging the economic benefits with the urgent need for establishing resilient production chains, social networks, sustainably-operating markets, and environmental protection.

To address the diversity of ongoing changes, the multivariate interactions of economic development, urbanization, digitalization, and other factors of globalization must be studied to reveal their combined effects on the sustainability of the economic, social, and environmental patterns across the continents. The papers included in this book highlight the urgent need for balanced economic development and comprehensive coverage of many sustainability–business areas. Over 90 contributors representing 40 universities and research institutions from seven countries discus a wide range of topics regarding the economic, production, financial, and social factors that influence the various dimensions of sustainability. Their findings are translated into workable approaches and policies for the benefit of the global economy, people, and environment.

Vasilii Erokhin, Gao Tianming, Andrei Jean Vasile

Editors

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Article

Capturing a Complexity of Nutritional, Environmental, and Economic Impacts on Selected Health Parameters in the Russian High North

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Abstract: The rapid pace of economic exploration of the Arctic against the backdrop of progressing environmental change put a high priority on improving understanding of health impacts in the northern communities. Deficiencies in the capability to capture the complexity of health-influencing parameters along with a lack of observations in circumpolar territories present major challenges to establishing credible projections of disease incidence across varying northern environments. It is thus crucial to reveal the relative contributions of coacting factors to provide a basis for sustainable solutions in the sphere of public health. In order to better understand the adverse effects associated with public health, this study employed six-stage multiple regression analysis of incidence rates of fourteen diseases (International Classification of Diseases (ICD-11) codes most widespread in the Russian Arctic) against a set of environmental, nutritional, and economic variables. Variance inflationary factor and best-subsets regression methods were used to eliminate collinearity between the parameters of regression models. To address the diversity of health impacts across northern environments, territories of the Arctic zone of Russia were categorized as (1) industrial sites, (2) urban agglomerations, (3) rural inland, and (4) coastline territories. It was suggested that, in Type 1 territories, public health parameters were most negatively affected by air and water pollution, in Type 2 territories—by low-nutrient diets, in Type 3 and Type 4 territories—by economic factors. It was found that in the Western parts of the Russian Arctic, poor quality of running water along with low access to the quality-assured sources of water might increase the exposure to infectious and parasitic diseases and diseases of the circulatory, respiratory, and genitourinary systems. Low living standards across the Russian Arctic challenged the economic accessibility of adequate diets. In the cities, the nutritional transition to low-quality cheap market food correlated with a higher incidence of digestive system disorders, immune diseases, and neoplasms. In indigenous communities, the prevalence of low diversified diets based on traditional food correlated with the increase in the incidence rates of nutritional and metabolic diseases.

Keywords: Arctic; environment; food security; health; nutrition

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1. Introduction

Over the previous decades, many studies, including those conducted in the framework of the Arctic Monitoring and Assessment Program (AMAP), have explored major aspects of public health in circumpolar communities, as well as assessed various stressors on human populations living in the North [1]. The Arctic, however, is changing rapidly in many ways. The once established patterns are transforming and bringing new potential risks to human health, such as contaminants, climate change, industrialization, urbanization, economic disruptions, and nutritional transitions. Among the current health effects, whose study is prioritized by the AMAP, are immunological, neurobehavioral, cardiovascular, metabolic, diabetogenic, developmental, reproductive, endocrine, and epigenetic [2]. To address the diversity of ongoing changes, there is a need to investigate multivariate interactions of environmental contaminants, dietary nutrients, and other factors and reveal their combined effects on health outcomes across Arctic communities [3].

Air pollution in the Arctic has been emerging as one of the threats to ecosystems and public health since the 1950s [4]. According to Arnold et al. [5], Arctic air pollution includes harmful trace gases, such as tropospheric ozone, particles, such as black carbon and sulfate, and toxic substances, such as polycyclic aromatic hydrocarbons. They are responsible for detrimental effects on human health even at low concentrations [6,7], ranging from physiological changes in pulmonary functions and the respiratory and cardiovascular systems to premature death [8]. Pope et al. [9] and Dockery et al. [10] found out that long-term exposure to fine particles and sulfur oxide-related air pollution was positively associated with death from lung cancer and cardiopulmonary. Naess et al. [11] discovered the particularly strong effects of the concentration of air pollution on chronic obstructive pulmonary disease.

Increased air pollution due to the ongoing industrialization and urbanization in the Arctic creates new challenges in relation to the quality of water, sanitation, and wastewater handling [12]. According to Dudley et al. [13] and Parkinson et al. [14], environmental disruptions in the North could spur the discharge of pathogenic microorganisms from wastewater treatment systems into marine and freshwater environments, emerging human health risks. Out of four types of water and infectious diseases categorized by White et al. [15], two are believed to be of crucial importance in the Arctic: waterborne infectious acquired by consumption of contaminated water and water-washed diseases acquired through person-to-person spread that can be interrupted by the use of water for washing [16]. Hennessy et al. [17] demonstrated a direct positive association between the lack of complete plumbing and higher incidence rates of respiratory and skin infections. The households with in-home water service have lower infant hospitalization rates for pneumonia and respiratory syncytial virus [18]. An exposure to inappropriately treated wastewater is recognized as one of the reasons for higher rates of infectious diseases in circumpolar communities, such as tuberculosis and methicillin-resistant *Staphylococcus aureus* [19,20].

The majority of previous studies on environmental impacts on health in the Arctic focused mainly on persistent organic pollutants (POPs) and metals [2,21]. Stockholm Convention recognizes that Arctic ecosystems and indigenous communities are particularly at risk because of the biomagnification of POPs [22]. However, identified threats from POPs and other contaminants have emerged public health concerns in the Arctic and reduced confidence in understanding the full picture of environmental impacts on health [23]. Apart from POPs, the Arctic environment is increasingly affected by new chemicals of emerging concern (CECs), such as current use pesticides, pharmaceuticals, and personal care products, and per- and polyfluoroalkyl substances [24], but current understanding of their health outcomes is limited. In large parts of the Arctic, for some CECs, there is a general lack of toxicological and other data that are needed to better understand health issues related to such compounds and for health risk assessments [25]. For instance, no reliable environmental data have been available from Russia, where spatial and temporal patterns of air pollutant emissions and wastewater discharge are poorly reported by the manufacturers and thus remain generally unknown. Arctic zone of Russia is one of the major centers for the production of fluoropolymers with manufacturers that have not signed on to stewardship programs to reduce long-chain perfluoroalkyl carboxylic and sulfonic acids in products [26]. For some CECs used in consumer products (siloxanes and phthalates), concentrations have been found to be higher near settlements and urban sites, particularly, in receiving waters impacted by sewage effluents [22,25].

Alongside with air and water pollution, the fact of poorer nutritional status of people in the Arctic communities of Russia compared to other parts of the country is believed to be one of the most adverse impacts on public health [27,28]. A poor-quality diet has long been associated with increasing obesity, diabetes, and glucose intolerance in many circumpolar communities [29]. In the Arctic zone of Russia, there are critical gaps in per capita consumption of milk and dairy products (about 55% below the national average), eggs, potatoes, and bread (45% lower each), and meat and meat products (30% lower) [30]. Due to the shortages of milk and dairy products, vegetables, and fruits, there is a shift of macronutrients in the diet towards carbohydrates (an abundance of sugar, confectioneries, bread, pasta, cereals) and, therefore, a lack of almost all types of vitamins, mineral nutrients (particularly calcium, phosphorus, magnesium, potassium, iodine, zinc, fluorine, etc.), and contamination of food by pesticides, metals, antibiotics, nitrates, and biological agents.

Many studies have advocated traditional food as a premier source of healthy diets and improvement of public health parameters in indigenous communities. Kuhnlein et al. [31] and Lambden et al. [32] considered traditional food as critical for providing many essential nutrients in balanced diets and recognized the progressing transition to high-energy market food in circumpolar communities as a basis for obesity and other related health problems. However, due to climate change and environmental pollution, traditional food is becoming a less obvious solution to health problems in the North. Concentrations of some CECs are increasing in Arctic air and wildlife, indicating their potential for bioaccumulation and biomagnification, including in food webs [33]. Climate change acts through alteration of food web pathways for contaminants [34], while pollution increases the risk of disease transfer from animals to humans as a large volume of marine and terrestrial wildlife is consumed by humans in the Arctic, often raw and inadequately frozen [35]. Dudarev et al. [36,37] found that blubber of marine mammals in Chukotka was highly contaminated by POPs and some metals, which was the reason for the high exposure to those contaminants by indigenous people whose diets included marine mammals. The higher temperature of ocean water moves warmer marine species towards the northern latitudes [38]. Along with the change of the polar water habitats and the effect of ocean acidification, such migrations bring new biological threats to the health of the Arctic inhabitants (diseases and microorganisms previously not met in the North).

Along with the environmental and nutritional imbalances, northern territories report higher morbidity and incidence rates of many diseases and health disorders compared to the national average [39,40] (Figure 1).

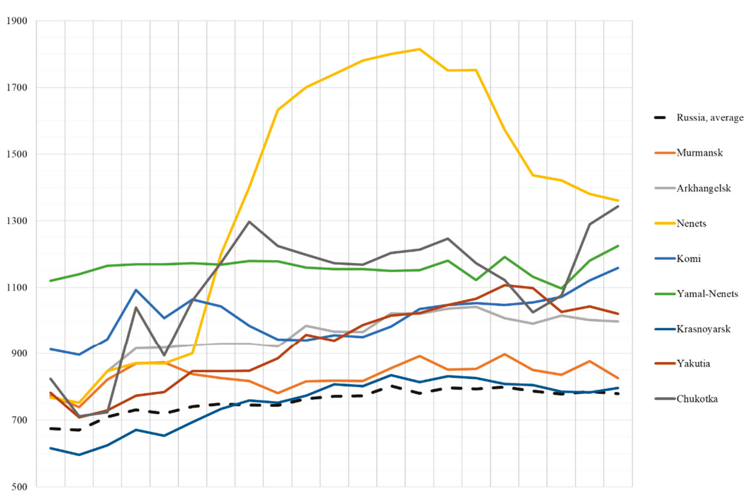

Figure 1. Morbidity across the Arctic territories of Russia, cases registered per 1000 people. Source: authors' development based on the Federal Service of State Statistics of the Russian Federation [41].

The major health issues are the diseases of the respiratory, genitourinary, and digestive systems (Table 1); the extremes recorded in the Nenets and Yamal-Nenets autonomous districts.

Table 1. Major diseases and health disorders in the Russian Arctic, average in 1997–2017, incidence rates per 1000 people.

Diseases and Health Disorders *	Russia	Arctic Zone of Russia	Territories **							
			1	2	3	4	5	6	7	8
Diseases of the respiratory system	333.66	430.46	366.94	404.63	561.92	464.59	435.86	273.94	416.65	519.18
Diseases of the genitourinary system	47.61	62.00	49.56	55.88	108.71	60.25	73.12	45.80	47.10	55.60
Diseases of the skin and subcutaneous tissue	46.02	56.34	50.95	48.64	69.04	70.11	56.09	45.22	54.09	54.86
Diseases of the digestive system	34.84	53.36	29.81	48.63	106.31	32.85	53.38	35.27	66.30	54.29
Infectious and parasitic diseases	31.07	47.08	42.44	49.63	66.63	54.19	49.60	39.49	34.45	40.22
Diseases of the nervous system	15.87	25.20	18.59	18.60	28.76	22.22	34.09	20.57	32.21	26.58
Diseases of the circulatory system	28.44	23.62	17.78	23.16	32.65	17.81	21.54	27.04	24.67	24.88
Endocrine, nutritional, and metabolic diseases	11.52	14.34	14.05	11.01	26.94	12.14	13.67	9.92	14.87	12.12
Neoplasms	11.13	11.23	12.57	10.09	12.86	10.56	12.69	12.13	9.14	9.76
Diseases of the blood and blood-forming organs	4.68	5.49	3.01	5.11	10.24	5.31	5.34	3.57	5.71	5.63

Note: * In descending order of the incidence rates across the Arctic zone of Russia; ** 1: Murmansk region; 2: Arkhangelsk region; 3: Nenets Autonomous District; 4: Komi Republic; 5: Yamal-Nenets Autonomous District; 6: Krasnoyarsk region; 7: Republic of Sakha (Yakutia); 8: Chukotka Autonomous District. Source: authors' development based on the Federal Service of State Statistics of the Russian Federation [41].

While Schmale et al. [42], Law and Stohl [43], Shindell et al. [44], and Kuhnlein et al. [31], among others, conducted the estimates of Arctic-specific disease incidence through environmental and nutritional impacts, a question remains whether particular public health parameters might experience the effects of economic factors [45]. Chen and Kan [8] recognized the people with low socioeconomic status as high-risk subgroups in terms of proneness to respiratory, cardiovascular, and other health effects. During the times of economic and social transformations in Russia in the 1990–2000s, the environmental situation in the Arctic deteriorated substantially with by-all-means emergence of extractive industries. Larsen and Fondahl [46] expected that the industrialization and urbanization trends in the Arctic accelerate in the future. The emissions of air pollutants and wastewater discharge will increase and mostly be emitted around existing industrial sites and human settlements. Due to the environmental disruptions of traditional sources of food and water, circumpolar communities have become increasingly vulnerable to economic insecurity [47]. Morozova et al. [48], Erokhin [49], and Liefert and Liefert [50] reported degrading purchasing power of population in Russia, which resulted in the redistribution of family means in favor of food, as well as a shift to less expensive food products and more affordable sources of proteins of lower quality and nutrition value [51,52].

Another question that emerges is whether particular circumpolar territories might have health impacts different from other Arctic regions and whether populations in various environmental and economic patterns respond differently to the varying combinations of influence parameters. One of the priorities declared by the AMAP Human Health program is tailoring health-related studies in the Arctic to address local issues [2]. Adlard et al. [3] and Weihe et al. [53] made a similar recommendation to consider local specifics and allowed for better cross-territorial comparisons. Chowdhury and Dey [54] and Schmale et al. [42] found that disease incidence rates varied dramatically between Arctic countries but also between the territories within a country. As the per-territory disruptions of public health are becoming increasingly complex, identifying individual factors that affect them is crucial [55,56]. In this study, an attempt was made to capture overlapping environmental, nutritional, and economic dimensions and understand their impacts on selected diseases in different types of circumpolar territories.

2. Materials and Methods

Based on the previous discussion of diversified public health impacts in the Arctic, the authors applied multiple regression analysis to reveal the variables X_n that affect the incidence rates of health disorders Y_n. The six-stage algorithm was employed (Figure 2).

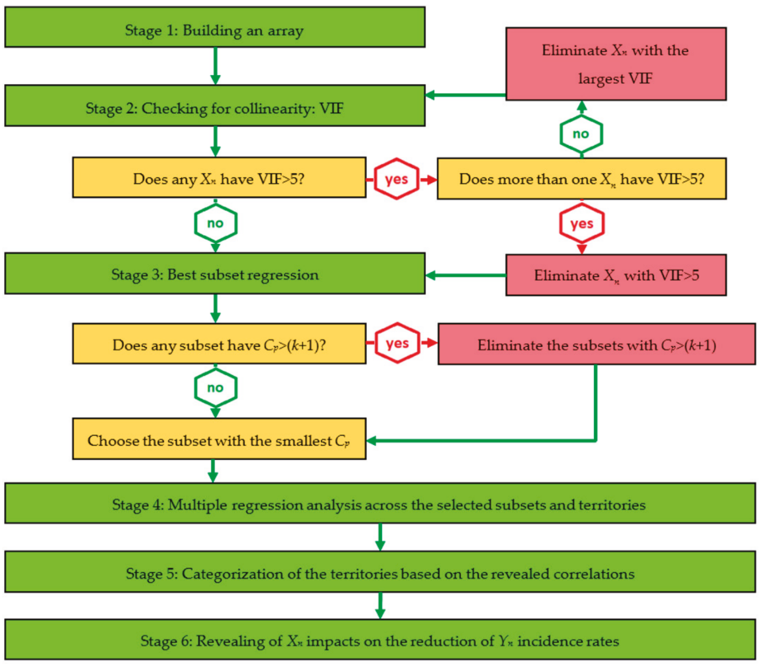

Figure 2. Study flow algorithm. Source: authors' development.

The study started with a selection of X_n regressors to be considered for inclusion in the model and development of the regression model (Stage 1). To avoid redundancy, variance inflationary factor (VIF) was computed for each X_n at Stage 2. Based on the criteria developed by Snee [57] and further applied by Kutner et al. [58], Montgomery et al. [59], and Ermakov et al. [60], that VIF values should be less than 5, those X_n for which $VIF > 5$ were excluded from the model. At Stage 3, a best-subsets regression was performed with the remaining X_n for all models. To finalize the collinearity test, the parameters of adjusted R^2 [61,62] and Mallows' C_p statistic [63–66] were computed for each subset. The subsets with $C_p > (k + 1)$ were eliminated; the study proceeded with those "best" subsets for which relative C_p were the lowest and/or adjusted R^2 were high. At Stage 4, multiple regression analysis of the models chosen was performed across Y_n regressands and territories. The revealed correlations allowed us to categorize the territories based on several parameters (Stage 5) and discover the effects of X_n regressors on Y_n regressands (Stage 6).

2.1. Stage 1

The categorization of major types of diseases was made according to the 11th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-11) [67] of the World Health Organization (WHO). Out of 26 ICD-11 codes, fourteen types of diseases were included in the study as Y_n regressands—those repeatedly reported by the WHO and many scholars among the most widespread health problems in both indigenous communities and urban settlements in the Arctic [68–70] (Table 2).

Table 2. Types of diseases included in the model as regressands.

Index	Regressands
Y_1	Certain infectious and parasitic diseases
Y_2	Neoplasms
Y_3	Diseases of the blood and blood-forming organs and disorders involving the immune mechanism
Y_4	Endocrine, nutritional, and metabolic diseases
Y_5	Diseases of the nervous system
Y_6	Diseases of the eye and adnexa
Y_7	Diseases of the ear and mastoid process
Y_8	Diseases of the circulatory system
Y_9	Diseases of the respiratory system
Y_{10}	Diseases of the digestive system
Y_{11}	Diseases of the skin and subcutaneous tissue
Y_{12}	Diseases of the musculoskeletal system and connective tissue
Y_{13}	Diseases of the genitourinary system
Y_{14}	Congenital malformations, deformations, and chromosomal abnormalities

Note: for all Y_n, the measure is the incidence rate per 1000 people. Source: authors' development.

An array of X_n regressors was established along with three types of variables, reflecting environmental ($X_{1–6}$), nutritional ($X_{7–12}$), and economic ($X_{13–16}$) dimensions of health-related effects (Table 3).

Table 3. Regressors included in the model.

Index	Regressors	Measure
X_1	Air pollutant emissions	Thousand tons
X_2	The capture of air pollutant emissions	Thousand tons
X_3	Freshwater utilization	Mln m^3
X_4	Recycled and reused water	Mln m^3
X_5	Wastewater discharge into the surface and underground water sources	Mln m^3
X_6	Percentage of households having running water available in their homes	%
X_7	Per capita consumption of meat products	kg/year
X_8	Per capita consumption of dairy products	kg/year
X_9	Per capita consumption of vegetables	kg/year
X_{10}	Per capita consumption of bread	kg/year
X_{11}	Per capita consumption of fish and marine mammals	kg/year
X_{12}	Traditional food proportion in a diet	%
X_{13}	The proportion of households with a hunter, a herder, or a fisherman in a family	%
X_{14}	The real value of cash incomes	Percentage over the previous year
X_{15}	The proportion of the population living below a minimum subsistence income	%
X_{16}	The proportion of food expenditures in total household's expenditures	%

Source: authors' development.

Physical environment, including quality of the air, safe drinking water, and adequate sanitary facilities, is one of the critical parameters of public health in the Arctic [71,72]. Despite the large gaps and significant uncertainties, which exist around quantification of influence of Arctic air pollution on public health [6], emissions can be severe, negatively affecting public health [42], particularly around the Russian cities of Norilsk, Vorkuta, and Monchegorsk, the areas of highest air pollution in the Arctic [5,73]. Nilsson et al. [47], Parkinson and Butler [74], and Thomas et al. [75] reported waterborne infectious diseases among the people living in the circumpolar territories in many Nordic countries.

Nutritional effects on health are measured as per capita consumption of major food products, including meat, fish, dairy, vegetables, and bread [49,76]. A parameter of traditional food proportion in a diet was included in the array like the one relevant in circumpolar and, particularly, indigenous communities. Many authors consider traditional food systems as essential sources of nutrients, n-3 polyunsaturated fatty acids [77], and vitamins C, B2, and B12 [78]. Sheehy et al. [79] reported that more traditional foods in a diet translated into greater dietary adequacy for proteins and a number of vitamins and minerals, including vitamin A, several B-vitamins, iron, zinc, magnesium, potassium, sodium, and selenium. According to Wesche and Chan [80], traditional food reduces the intake of saturated fats, sucrose, and excess carbohydrates that often are found in marketed food. However, while most of the studies report health advantages of traditional food patterns, including a lower incidence of cardiovascular disease [81], stability of gut microbiome [82], sources of bioavailable iron [83], among others, there are alternative findings of adverse health effects of traditional food. For instance, Jeppesen et al. [84] concluded that traditional food was positively associated with type 2 diabetes mellitus, impaired fasting glucose, and fasting plasma glucose. Bjerregaard et al. [85] found that impaired fasting glucose increased among the Inuit in Greenland with the consumption of traditional marine food, which might result in impaired insulin secretion – a link revealed by Færch et al. [86] and Weyer et al. [87,88]. Jørgensen et al. [89] discovered a strong association between persistent organic pollutants in a traditional seafood and low insulin secretion, while Kuhnlein [90] found higher health risks of traditional food systems containing sea mammals due to environmental pollution and increased organochlorine consumption. Contamination of traditional food sources is one of the reasons for lower β-cell function, an important early stage in the development of type 2 diabetes mellitus.

Among economic variables, the real value of cash incomes is used as one of the parameters of the economic accessibility of adequate healthcare services and nutrition [91]. The proportion of the population living below a minimum subsistence income along with the proportion of food expenditures in total household expenditures is the measures of economic accessibility of a healthy diet, which are commonly used by the Food and Agriculture Organization of the United Nations (FAO) [92]. They were included in the array to reflect the ability of households to generate sufficient income, which, along with their own production, can be used to meet food needs. The selection was also based on the idea that within a monetary dimension, access to food required a steady income to ensure a consistent, year-round supply of high-quality goods in the stores and a ready supply of healthy wildlife to be harvested [93]. Indigenous people do not rely much on marketed food; their food expenditures are low. But they still have to deal with the high cost of many commodities, such as oil, fuel, and transportation, essential for hunting, fishing, or reindeer herding activities [33]. Since the primary means for obtaining and producing food in indigenous communities are provided by hunting, herding, fishing, and gathering activities, a presence of a hunter, a herder, or a fisherman in a family is used as one of the economic regressors.

For all Y_n and X_n, the data were obtained from the Federal Service of State Statistics of the Russian Federation [41], as well as from the authors' calculations.

2.2. Stage 2

A critical issue in building multiple regression models is how to eliminate independent variables with strong correlations between each other, whether positive or negative. Identification of collinear variables involves several approaches, one of the most widely used being the variance inflationary factor (VIF) (Equation (1)). It has been successfully applied for measuring and reduction collinearity, for instance, by Zainodin et al. [94] in an ordinary least squares regression analysis, Bowerman and O'Connell [95] in expressing independent variables in regression models as the functions of the remaining regressors, and Dan and Vallant [96] in the analysis of variances between independent variables in complex survey data.

$$VIF = \frac{1}{1 - R_n^2} \tag{1}$$

where VIF = variance inflationary factor; R_n^2 = coefficient of multiple determination for a regression model.

According to Snee [57], Kutner et al. [58], Montgomery et al. [59], and Levine et al. [61], collinearity between the variables is considered high when VIF exceeds 5. The approach used at Stage 2 was that if VIF for a particular set of X_n regressors was less than 5, these regressors were included in the model. In case it was not, the X_n variable was eliminated from a subset. The computation was made across eight subsets of X_n variables, one per territory included in the study (see Stage 4 for the list of territories).

2.3. Stage 3

Having eliminated the variables with high VIF, we then attempted to determine whether the resulting subsets all yield appropriate models with low redundancy. Most commonly, such a task is solved by employing stepwise regression, which allows revealing the optimal regression model without examining all subsets [97–100]. For many decades, this approach to regression model building has been extensively used in statistics and econometrics as an appropriate trade-off between time expenditures and model performance [101–103]. Nowadays, a stepwise regression model building commonly employs the best subsets approach (BSA) that allows evaluating all possible regression models for a given set of regressors in a timely-effective and accurate manner [104–106].

Generally, the BSA-based checking of regression models involves a parameter of adjusted R^2 [107], which adjusts the R^2 of each subset to account for the number of regressors and the sample size [61]. In this study, the employment of adjusted R^2 instead of R^2 was preferable due to the need to compare Stage 2 subsets with different numbers of X_n. Among the competing subsets, the study proceeded with the one with the largest adjusted R^2. In addition to adjusted R^2, when the goal is to find the most appropriate model involving multitude subsets of regressors, a criterion of Mallows' C_p statistic (Equation (2)) is generally applied [60,61]. Examples include checking matchings between the subsets [108], model averaging [109–111], measuring the deviations from perfect rankings [112], and model selection [113].

$$C_p = \frac{\left(1 - R_k^2\right)(n - T)}{1 - R_T^2} - (n - 2(k + 1)) \tag{2}$$

where C_p = Mallow's C_p statistic; n = number of observations; k = number of regressors; T = total number of variables in the full model, including the intercept; R_k^2 = coefficient of multiple determination for a model with k regressors; R_T^2 = coefficient of multiple determination for a model with all T variables.

In this study, C_p was applied as a tool to measure the differences between the models constructed at Stage 2 and optimal (or true) models that best explain the correlations. The idea was that the closer C_p to the number of variables included in a subset, the more accurate would be the model (only random differences from the optimal model might occur). Thus, Stage 3 resulted in identifying the subsets whose C_p were close to or below (k + 1). In total, eight subsets of independent X_n variables were built for eight territories.

2.4. Stage 4

At Stage 4, multiple regression analysis was performed for all combinations of the selected non-collinear X_n aggregated in fourteen multitudes separately for each Y_n. The aim was to reveal the variables with the highest positive, positive, negative, and the most negative effects on respected Y_n in the Russian Arctic, in general, as well as separately in eight territories included in the Arctic zone of Russia (Figure 3):

1. Territory 1: Murmansk region;
2. Territory 2: Arkhangelsk region (Arkhangelsk, Mezensk municipal area, Novaya Zemlya, Novodvinsk, Onezh municipal area, Primorsk municipal area, Severodvinsk);
3. Territory 3: Nenets Autonomous District;
4. Territory 4: Komi Republic (Vorkuta municipal area);
5. Territory 5: Yamal-Nenets Autonomous District;
6. Territory 6: Krasnoyarsk Krai (Norilsk, Taimyr Dolgan-Nenets municipal area, Turukhansk district);
7. Territory 7: Republic of Sakha (Yakutia) (Allaikhovsky district, Anabar national (Dolgan-Evenk) district, Bulunsky district, Nizhnekolymsky district, Ust-Yansky district);
8. Territory 8: Chukotka Autonomous District.

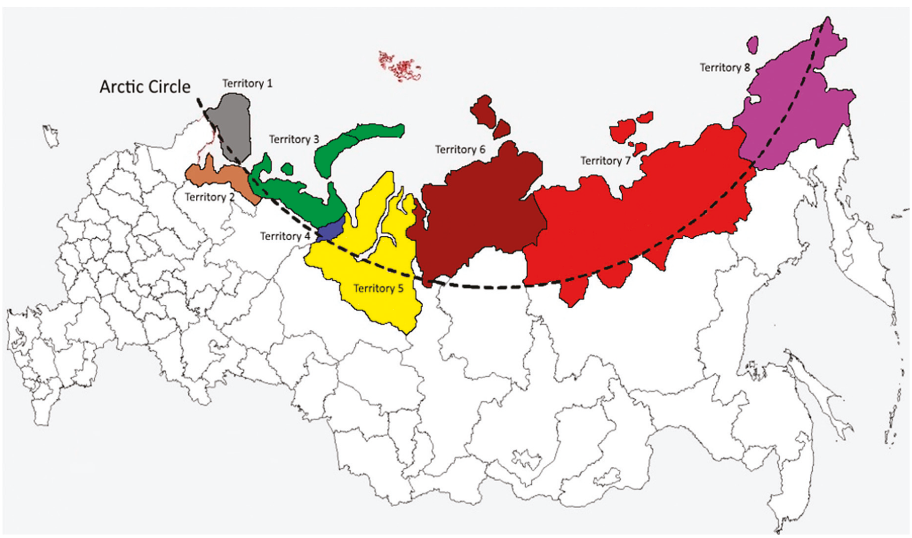

Figure 3. Territories of the Arctic zone of Russia included in the study. Source: authors' development.

2.5. Stage 5

To reflect the division of regressors into three dimensions and make cross-country comparisons possible, the diversity of effects on public health was addressed by categorizing the territories based on the respective parameters:

1. Type 1: territories adjacent to industrial agglomerations, where a level of air and water pollution was higher compared to the mean of the sample.
2. Type 2: territories adjacent to urban agglomerations, where a share of market food in consumption was higher compared to the mean of the sample.
3. Type 3: rural inland territories, where the traditional diets of indigenous people were based on meat.
4. Type 4: rural coastline territories, where the traditional diets of indigenous people were based on fish and marine mammals.

It was supposed that, in different types of territories, the incidence rates of Y_n diseases and related health problems were affected by different X_n variables, particularly:

Hypothesis 1 (H1): *In Type 1 territories, the strongest influence over Y_n is exerted by environmental variables $X_{1–6}$.*

Hypothesis 2 (H2): *In Type 2 territories, the strongest influence over Y_n is exerted by nutritional variables $X_{7–12}$.*

Hypothesis 3 (H3): *In Type 3 and Type 4 territories, the strongest influence over Y_n is exerted by economic variables $X_{13–16}$ and traditional food proportion in a diet X_{12}.*

2.6. Stage 6

To test the hypotheses, positive and negative impacts of X_n variables on the reduction of incidence rates of Y_n were revealed separately for the four types of circumpolar territories. Positive effects were differentiated as high positive (HP), positive (P), and moderately positive (MP); the negative ones—extremely negative (EN), negative (N), and moderately negative (MN). To decide on the degree of positive or negative effect, maximum and minimum extremes (X_{max} and X_{min}, respectively) were excluded from the calculation, and then a mean value X_{med} was determined for each of the multitudes (Equation (3)):

$$X_{med} = \frac{\sum X_n - X_{max} - X_{min}}{n-2} \quad (3)$$

A degree of the effect of X_n on Y_n was recognized, when a value of X_n fell into one of the intervals (Table 4).

Table 4. X_n intervals and effects on Y_n.

Intervals	Effects on Y_n
$(X_{max} + X_{med})/2 \geq X_{med} \geq (X_{min} + X_{med})/2$	Positive (P) Negative (N)
$X_{max} \geq X_n > (X_{max} + X_{med})/2$	High positive (HP) Extremely negative (EN)
$(X_{min} + X_{med})/2 > X_n \geq X_{min}$	Moderately positive (MP) Moderately negative (MN)

Note: X_n – regressors, Y_n – regressands. Source: authors' development.

3. Results

The results are presented across five sub-sections in accordance with stages 2–6 of the study flow algorithm (Figure 2). We first checked the array of X_n variables established at stage 1 for collinearity (Section 3.1.), then selected the best subsets from derived multitudes (Section 3.2.). After that, we performed multiple regression analysis in selected subsets and generalized the effects of X_n on Y_n for the entire Arctic Zone of Russia (Section 3.3.). Based on the identified correlations, we then categorized the territories into types (Section 3.4.), revealed positive and negative determinants of incidence rates across them, and tested out hypotheses (Section 3.5.).

3.1. Checking X_n for Collinearity

Collinearity checks were performed in 128 multitudes of $X_{1–16}$ variables in eight territories included in the study. Regression models were computed with all independent variables to find *VIF*s. Application of $VIF > 5$ criteria resulted in the elimination of high-collinear X_n variables from the models in respective territories (Table 5)—some of the water-use and environmental variables in the western and central territories of the Russian Arctic and economic variables in the Far East.

Table 5. Coefficient of multiple determination (R^2) and variance inflationary factor (*VIF*) values of $X_{1–16}$ variables to be selected for the model.

Variables	Values per Territories 1–8															
	1		2		3		4		5		6		7		8	
	R^2	*VIF*	R^2	*VIF*	R^2	*VIF*	R^2	*VIF*	R^2	*VIF*	R^2	*VIF*	R^2	*VIF*	R^2	*VIF*
X_1	0.658	2.924	0.505	2.020	0.883	8.547 *	0.722	3.597	0.664	2.976	0.684	3.165	0.583	2.398	0.565	2.299
X_2	0.703	3.367	0.782	4.587	0.908	10.870 *	0.784	4.630	0.866	7.463 *	0.821	5.587 *	0.502	2.008	0.632	2.717
X_3	0.794	4.854	0.669	3.021	0.734	3.759	0.693	3.257	0.729	3.690	0.533	2.141	0.668	3.012	0.602	2.513
X_4	0.892	9.259 *	0.809	5.236 *	0.729	3.690	0.856	6.944 *	0.768	4.310	0.738	3.817	0.771	4.367	0.718	3.546
X_5	0.707	3.413	0.741	3.861	0.710	3.448	0.923	12.987 *	0.901	10.101 *	0.453	1.828	0.359	1.560	0.391	1.642
X_6	0.826	5.747 *	0.840	6.250 *	0.780	4.545	0.765	4.255	0.814	5.376 *	0.557	2.257	0.538	2.165	0.597	2.481
X_7	0.238	1.312	0.304	1.437	0.338	1.511	0.404	1.678	0.327	1.486	0.289	1.406	0.244	1.323	0.248	1.330
X_8	0.572	2.336	0.620	2.632	0.547	2.208	0.528	2.119	0.488	1.953	0.390	1.639	0.372	1.592	0.447	1.808
X_9	0.729	3.690	0.783	4.608	0.702	3.356	0.675	3.077	0.662	2.959	0.582	2.392	0.497	1.988	0.523	2.096
X_{10}	0.448	1.812	0.426	1.742	0.413	1.704	0.449	1.815	0.493	1.972	0.299	1.427	0.265	1.361	0.298	1.425
X_{11}	0.582	2.392	0.605	2.532	0.526	2.110	0.572	2.336	0.504	2.016	0.451	1.821	0.493	1.972	0.513	2.053
X_{12}	0.730	3.704	0.752	4.032	0.699	3.322	0.730	3.704	0.726	3.650	0.504	2.016	0.478	1.916	0.571	2.331
X_{13}	0.401	1.669	0.369	1.585	0.454	1.832	0.467	1.876	0.552	2.232	0.373	1.595	0.401	1.669	0.389	1.637
X_{14}	0.385	1.626	0.358	1.558	0.405	1.681	0.501	2.004	0.487	1.949	0.596	2.475	0.660	2.941	0.725	3.636
X_{15}	0.772	4.386	0.730	3.704	0.683	3.155	0.656	2.907	0.702	3.356	0.882	8.475 *	0.854	6.849 *	0.836	6.098 *
X_{16}	0.745	3.922	0.777	4.484	0.761	4.184	0.700	3.333	0.711	3.460	0.847	6.536 *	0.871	7.752 *	0.883	8.547 *

Note: * collinearity detected. Source: authors' development

3.2. *Selection of the Best Subsets*

Best-subsets stepwise regression with the remaining X_n allowed to identify several more variables with high collinearity: X_{13} in territories 1 and 2, X_5 in territory 2, X_3 in territory 3, X_4 in territory 5, and X_4 in territory 6. Based on the parameters of adjusted R^2 and Mallows' C_p statistic, the best subsets of variables (one per territory) were chosen out of competing multitudes (Table 6).

Table 6. Subsets of X_n variables selected for the inclusion in the model per territories.

Territories	Adjusted R^2	Mallows' C_p Statistic	Number of Variables (k+1)	Variables	
				Included in the Best Subsets	Eliminated from the Model
1	0.738	9.185	14	$X_{1–3}$, X_5, $X_{7–12}$, $X_{14–16}$	X_4, X_6, X_{13}
2	0.641	10.117	13	$X_{1–3}$, $X_{7–11}$, $X_{12–16}$	$X_{4–6}$, X_{13}
3	0.790	5.499	14	$X_{4–16}$	$X_{1–3}$
4	0.704	11.343	15	$X_{1–3}$, $X_{6–16}$	X_4, X_5
5	0.529	8.170	13	X_1, X_3, $X_{7–16}$	X_2, $X_{4–6}$
6	0.674	12.274	13	X_1, X_3, $X_{5–14}$	X_2, X_4, X_{15}, X_{16}
7	0.742	10.398	15	$X_{1–14}$	X_{15}, X_{16}
8	0.787	13.926	15	$X_{1–14}$	X_{15}, X_{16}

Source: authors' development.

3.3. *Multiple regression*

Multiple regression analysis was performed in 112 multitudes (fourteen Y_n regressands and eight territories) with respective adjusted arrays of independent variables. High R^2 in individual multitudes and average R^2 demonstrated that all variations were well explained (Table 7).

Table 7. R^2 coefficients across the territories and regressands.

Regressands	Territories								Average/Y_n
	1	2	3	4	5	6	7	8	
Y_1	0.9362	0.9719	0.9394	0.9773	0.9274	0.9628	0.9548	0.9555	0.9532
Y_2	0.9459	0.9558	0.9428	0.9854	0.9556	0.9733	0.9729	0.9780	0.9637
Y_3	0.9638	0.9250	0.9551	0.9660	0.9781	0.9709	0.9882	0.9702	0.9647
Y_4	0.9721	0.9289	0.9483	0.9748	0.9770	0.9612	0.9446	0.9773	0.9605
Y_5	0.9690	0.9499	0.9444	0.9619	0.9733	0.9883	0.9895	0.9805	0.9696
Y_6	0.8882	0.9726	0.9702	0.9834	0.9712	0.9714	0.9697	0.9699	0.9621
Y_7	0.9314	0.9515	0.9619	0.9286	0.9843	0.9770	0.9726	0.9763	0.9605
Y_8	0.9792	0.9772	0.9825	0.9779	0.9708	0.9823	0.9711	0.9218	0.9704
Y_9	0.8513	0.9610	0.9803	0.9118	0.9755	0.9465	0.9835	0.9505	0.9451
Y_{10}	0.9619	0.8981	0.9814	0.9623	0.9357	0.9496	0.9804	0.9715	0.9551
Y_{11}	0.8474	0.9057	0.9810	0.8517	0.9689	0.9449	0.9566	0.9311	0.9234
Y_{12}	0.9317	0.9511	0.9882	0.9362	0.9544	0.9755	0.9709	0.9017	0.9512
Y_{13}	0.9440	0.8842	0.9507	0.9814	0.9725	0.9883	0.9745	0.9447	0.9550
Y_{14}	0.8863	0.9702	0.9415	0.9793	0.8813	0.8028	0.9330	0.8966	0.9114
Average/territory	0.9292	0.9431	0.9620	0.9556	0.9590	0.9568	0.9687	0.9518	0.9533

Source: authors' development.

Generalization of X_n values for eight territories allowed to reveal the health-related effects of independent variables in the entire Arctic Zone of Russia (Table 8). X_6, the percentage of households with available sources of running water, posed the most diverse effects on selected health parameters, from the highest positive to the most negative. Air and water pollution massively had a net detrimental effect on the incidence rates of the diseases under study (excluding X_4 eliminated from the subsets in most of the western territories of the Arctic Zone and X_2 not considered in territories 3, 5, and 6). Economic parameters (excluding high-collinear X_{15} and X_{16} in the eastern areas of the Arctic Zone) made a positive impact on the reduction of the incidence rates. The effects of nutritional variables varied across Y_n, the most positive being consumption of fish and marine mammals in case of the diseases of the circulatory and nervous systems.

Table 8. The effects of independent variables on Y_n: generalization for the Russian Arctic *.

	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9	Y_{10}	Y_{11}	Y_{12}	Y_{13}	Y_{14}
X_1	N	N	N	N	N	N	N	N	N	N	N	P	N	P
X_2	N	P	N	P	N	N	P	N	P	N	P	P	P	P
X_3	P	N	N	N	N	N	P	N	P	P	P	P	N	P
X_4	P	N	P	N	N	N	P	N	N	P	P	P	N	N
X_5	N	HP	N	N	P	P	EN	P	N	P	P	N	N	P
X_6	HP	EN	P	EN	HP	EN	HP	EN	EN	EN	HP	N	EN	HP
X_7	P	N	EN	P	N	N	N	N	P	P	N	N	HP	N
X_8	N	P	P	N	N	P	N	P	N	P	N	P	P	P
X_9	P	P	N	N	N	N	P	P	N	HP	N	N	P	N
X_{10}	P	N	N	P	N	P	N	N	P	N	N	N	N	N
X_{11}	N	P	HP	P	N	N	N	HP	P	P	P	P	N	EN
X_{12}	P	N	P	P	P	N	N	N	P	N	N	P	N	N
X_{13}	EN	P	P	HP	N	N	P	N	N	N	EN	EN	N	N
X_{14}	P	N	N	P	P	P	P	P	HP	P	P	P	N	N
X_{15}	P	N	N	P	EN	P	P	N	P	P	P	HP	P	N
X_{16}	P	P	N	N	N	HP	P	N	P	P	P	P	P	N

Note: * for particular X_n, the generalizations cover only those territories in which the respective X_n is included in the per-territorial models; HP—the highest positive impact of X_n on the reduction of Y_n; P—positive impact of X_n on the reduction of Y_n; N—negative impact of X_n on the reduction of Y_n; EN—extremely negative impact of X_n on the reduction of Y_n. Source: authors' development.

3.4. Categorization of the Territories

Categorization based on the level of pollutant emissions, the proportion of market food in the diets, and the per capita consumption of meat and fish allowed to classify four types of territories (Table 9).

Table 9. Types of the territories.

Type	Territory	Parameter Value, 1997–2017 Average	
		Arctic Zone	Territory
Type 1	Territory 5 Territory 6	$X_1 = 627.32$	$X_1 = 813.77$ $X_1 = 2672.13$
Type 2	Territory 1 Territory 2 Territory 4	$X_{12} = 51.64$	$X_{12} = 73.15$ $X_{12} = 80.02$ $X_{12} = 59.60$
Type 3	Territory 7	$X_7 = 63.46$	$X_7 = 89.76$
Type 4	Territory 8 Territory 3	$X_{11} = 17.99$	$X_{11} = 34.44$ $X_{11} = 23.58$

Source: authors' development.

Type 1 territories were those most intensively explored by Russian hydrocarbon and mineral companies. The group included the territories of Yamal-Nenets Autonomous District and three areas of Krasnoyarsk Krai-Norilsk and Taimyr Dolgan-Nenets municipal areas and Turukhansk district, where the highest level of air pollutant emissions was registered. The percentage of households with access to quality-assured sources of water was low. In territory 6, the volume of wastewater discharge into the surface and underground water sources was the highest in the Russian Arctic.

Type 2 included the territories of Murmansk and Archangelsk oblasts adjacent to the biggest cities and seaports in the Russian North, Murmansk, and Archangelsk, respectively. In Type 2 territories, people had predominantly westernized type of nutrition with a low proportion of traditional foods in their diets. Due to the low standards of living in Type 2 territories (in 2017, the proportion of the population living below a minimum subsistence income was 18.0%, 15.0%, and 13.5% in Komi Republic, Arkhangelsk, and Murmansk regions, respectively), there was registered underconsumption of meat and dairy products and vegetables.

Inland territories of Russian Arctic relatively remote from either urban or industrial agglomerations were recognized as Type 3 (Republic of Sakha) and Type 4 (Chukotka and Nenets autonomous districts). In Type 3 and 4 territories, diets of people were more traditional compared to the western parts of the Russian North, with a predominance of reindeer meat, fish, and marine mammals. The Yakuts are historically semi-nomadic hunters engaged in animal husbandry, focusing on reindeer herding [114], while people in Type 4 territories depended on fishing. In Chukotka, per capita consumption of meat was the lowest in the Russian Arctic—44 kg/year in 2017.

Despite the relatively similar reliance of diets on traditional food in Type 3 and Type 4 territories, the average incidence rates of diseases under study varied widely (Table 10). This finding supported the assumption that in different types of circumpolar territories, public health parameters are affected by different combinations of factors, nutritional ones being but a few of them.

Table 10. Incidence rates of Y_n diseases and related health problems across the territories of the Russian Arctic, average in 1997–2017, cases per 1000 people.

Diseases and Health Disorders	Territories				Russian Arctic
	Type 1	Type 2	Type 3	Type 4	
Y_1	44.55	48.75	34.45	53.43	45.30
Y_2	12.41	11.07	9.14	11.31	10.98
Y_3	4.45	4.48	5.71	7.94	5.65
Y_4	11.79	12.40	14.87	19.53	14.65
Y_5	27.33	19.80	32.21	27.67	26.75
Y_6	49.15	35.66	43.67	61.50	47.50
Y_7	29.22	28.53	21.84	37.35	29.24
Y_8	24.29	19.58	24.67	28.77	24.33
Y_9	354.90	412.05	416.65	540.55	431.04
Y_{10}	44.33	37.10	66.30	80.30	57.01
Y_{11}	50.66	56.57	54.09	62.80	56.03
Y_{12}	41.47	40.78	31.68	58.42	43.09
Y_{13}	59.46	55.23	47.10	82.16	60.99
Y_{14}	2.11	2.50	2.07	4.18	2.72

Source: authors' development.

3.5. Revealing the Correlations

To reveal the determinants of varying incidence rates across the four types of territories, the impacts of X_n factors were graded on a scale from high positive to extremely negative. Based on the previous results of collinearity checks and categorization of the territories, the following independent variables were eliminated from the models: in Type 1 territories—X_2 and X_4; in Type 2 territories—X_4 (X_6 and X_{13} were considered in territory 4 only, X_5—in territory 1); in Type 3 territories—X_{15} and X_{16}. The highest positive impact on public health was exerted by the quality of nutrition (consumption of fish and marine mammals and vegetables) in Type 1 and Type 3 territories, economic variables of income, poverty, and food expenditures in Type 2 and Type 3 territories, and quality of running water supply and wastewater treatment in Type 3 and Type 4 territories (Table 11).

Table 11. Positive effects of X_n variables on the reduction of Y_n.

	Type 1 Territories			Type 2 Territories			Type 3 Territories			Type 4 Territories		
	HP	P	MP	HP	P	MP	HP	P	MP	HP	P	MP
Y_1	X_9	X_{11}, X_{12}		X_{16}	X_7, X_{10}, X_{14}	X_9, X_{15}	X_6, X_{12}	X_{10}	X_4, X_2, X_3, X_9	X_5	X_6, X_8	X_{12}, X_4
Y_2	X_{11}, X_8	X_{13}, X_{10}, X_{14}	X_1	X_{13}	X_{16}, X_8	X_2, X_9, X_{14}	X_{13}, X_{14}	X_8	X_1, X_9	X_5	X_8, X_9, X_{13}	X_{14}, X_4
Y_3	X_{11}	X_8		X_7	X_9, X_{12}, X_{11}, X_3	X_{14}, X_2	X_6, X_{11}	X_8	X_1, X_3, X_{10}, X_{14}	X_{11}, X_5	X_4, X_7	X_{14}, X_8
Y_4	X_{11}, X_8	X_{12}	X_{14}, X_1	X_7, X_8	X_9, X_{15}	X_{14}, X_2, X_3	X_{14}	X_6, X_{11}	X_1, X_8	X_{11}, X_{10}, X_5	X_4, X_9, X_{12}	X_{14}, X_8
Y_5	X_6	X_{12}	X_1, X_5	X_{14}	X_8, X_9	X_3	X_6	X_{12}, X_{14}	X_5, X_2	X_5, X_{11}	X_{10}, X_{13}	X_8, X_7, X_{12}
Y_6	X_{11}, X_9	X_{12}, X_8	X_1, X_3, X_{10}	X_{16}	X_8, X_{10}	X_{12}	X_6, X_{11}	X_{10}, X_{14}	X_5, X_1, X_2, X_7	X_6	X_7	X_{14}, X_{12}
Y_7	X_7	X_9, X_{10}	X_{14}, X_3	X_{16}	X_8	X_{14}	X_6, X_{12}	X_{11}	X_2, X_4, X_{10}	X_6, X_{10}	X_4, X_8	X_{13}
Y_8	X_{11}	X_8, X_9	X_{12}	X_{15}	X_9	X_{10}, X_8, X_{14}	X_{11}, X_{14}	X_6	X_2, X_1, X_7	X_6, X_{11}	X_{10}, X_5	X_{14}, X_8
Y_9	X_9, X_{13}	X_{10}, X_{11}	X_{14}, X_3, X_8	X_{13}, X_{15}	X_7, X_{14}	X_1, X_3, X_8	X_{12}	X_5, X_{10}	X_4, X_2, X_3	X_5	X_{11}, X_7	X_8
Y_{10}	X_{11}, X_{13}	X_9, X_{10}	X_1, X_3	X_{13}, X_{15}	X_{10}, X_{16}	X_3, X_8, X_9	X_6	X_{11}, X_{12}, X_{14}	X_1, X_2	X_9, X_6	X_{10}, X_{11}	X_4, X_{12}, X_{14}
Y_{11}	X_{11}, X_9	X_7, X_{12}	X_3	X_{16}, X_{15}	$X_8, X_{11}, X_{13}, X_{14}$	X_3	X_6, X_{14}	X_{10}, X_{11}, X_{12}	X_4, X_1, X_2, X_7	X_6	X_8	X_4, X_{14}, X_{11}
Y_{12}	X_{11}	X_{10}, X_{13}	X_8	X_{13}	X_8	$X_1, X_3, X_{12}, X_{14}, X_{16}$	X_6, X_{11}	X_{10}, X_{14}	X_5, X_2, X_7, X_8	X_6, X_{11}	X_7, X_{15}, X_4	X_{12}, X_{14}
Y_{13}	X_{11}, X_7	X_{10}, X_{13}, X_{14}	X_3, X_9	X_{15}, X_{12}	X_7, X_9	X_2, X_{14}	X_{14}	X_6, X_{11}	X_2, X_1, X_7, X_8	X_6, X_5	X_8, X_{15}, X_{11}	X_{14}, X_4
Y_{14}	X_7	X_{10}		X_{15}	X_{14}, X_{12}	X_1, X_8, X_3	X_{14}	X_6	X_1, X_2, X_7, X_8	X_4, X_5	X_9, X_{10}	X_{13}, X_8

Note: HP—high positive, P—positive, MP—moderately positive. Source: authors' development.

The most negative impact on public health was exerted by low percentage of households with the running water supply in Type 1, 2, and 4 territories, wastewater discharge into surface and underground water reservoirs in Type 4 territories, consumption of meat products in Type 1 and 2 territories and bread in Type 2 territories, and low economic standards of living in Type 3 and 4 territories (Table 12).

Table 12. Negative effects of X_n variables on the reduction of Y_n.

	Type 1 Territories			Type 2 Territories			Type 3 Territories			Type 4 Territories		
	EN	N	MN	EN	N	MN	EN	N	MN	EN	N	MN
Y_1	X_7, X_{10}, X_{13}	X_8, X_{14}	X_1, X_3	X_8, X_{12}	X_{13}, X_{14}	X_1, X_2, X_3	X_{13}	X_{11}, X_{14}	X_7, X_8	X_7, X_{13}	X_{10}, X_9	X_{14}, X_{11}
Y_2	X_{12}, X_7	X_9	X_3	X_{12}, X_{10}	X_{15}, X_{11}, X_7	X_1, X_3	X_{12}, X_6	X_5, X_{10}	X_4, X_2, X_3	X_7, X_6	X_1, X_{12}	X_{11}, X_{10}
Y_3	X_7, X_{12}	X_6, X_{13}, X_{14}	X_3, X_{10}, X_1	X_{16}	X_{15}, X_{10}	X_8, X_1	X_7, X_{12}	X_5	X_2, X_9, X_{13}	X_3	X_6, X_{12}, X_{13}	X_{10}, X_9
Y_4	X_6	X_7, X_{10}	X_{13}, X_9	X_{16}	X_{12}, X_{11}	X_5, X_1, X_{10}	X_{12}	X_5, X_7, X_9, X_{13}	X_2, X_3, X_4	X_6	X_7	X_{16}
Y_5	X_{10}	X_{11}, X_7, X_{13}	X_8, X_3, X_{14}	X_{11}, X_7	X_{12}, X_{16}, X_{15}	X_2, X_1	X_{13}	X_7, X_9, X_{10}	X_4, X_1, X_3	X_9, X_6	X_3	X_{14}, X_4
Y_6	X_7	X_{15}, X_{14}	X_{13}	X_6	$X_9, X_{11}, X_{14}, X_{15}$	X_3, X_2, X_1, X_7	X_{13}	X_9, X_{12}	X_4, X_3	X_5, X_{13}	X_8, X_9, X_{10}	X_{11}, X_4
Y_7	X_{11}, X_8	X_{12}, X_{13}	X_1, X_{16}	X_6	$X_{15}, X_9, X_{10}, X_{12}$	X_2, X_1, X_3, X_7	X_{13}	X_7, X_9, X_{14}	X_1, X_5, X_8	X_5	X_9, X_{11}, X_7	X_{14}, X_{12}
Y_8	X_{10}, X_7	X_{13}, X_{14}	X_3, X_1	X_6	X_7, X_{11}, X_{12}	X_2, X_3, X_{16}, X_1	X_{12}	X_9, X_{10}, X_{13}	X_4, X_3, X_5	X_{12}, X_{13}	X_4, X_7	X_3, X_9
Y_9	X_6	X_7, X_5	X_{12}, X_1	X_{16}	X_{10}, X_{11}, X_{12}	X_2, X_5, X_9	X_{13}	X_6, X_8, X_{11}	X_7, X_1, X_9	X_6, X_{12}	X_4, X_{10}, X_{13}	X_9, X_{14}
Y_{10}	X_{12}	X_{14}	X_8, X_7	X_6	X_7, X_{14}, X_{11}	X_2, X_1	X_9	X_{13}	X_4, X_3, X_5, X_8	X_5, X_{13}	X_3, X_7	X_8, X_{15}
Y_{11}	X_{10}, X_8	X_{13}, X_{14}	X_1	X_7	X_9, X_{12}, X_{10}	X_2, X_1	X_{13}	X_9	X_3, X_8	X_5, X_{13}	X_9, X_{10}, X_{12}	X_7
Y_{12}	X_7, X_6	X_{12}, X_{14}	X_3, X_1, X_9	X_7	X_{10}, X_{11}, X_{15}	X_2, X_9	X_{13}, X_9	X_{12}	X_4, X_3	X_5, X_{13}	X_8, X_9	X_{10}
Y_{13}	X_{15}, X_6	X_8, X_{12}	X_5, X_1	X_6	X_8, X_{10}, X_{11}	X_3, X_1, X_{16}	X_{12}	X_9, X_{10}, X_{13}	X_4, X_3, X_5	X_9, X_{13}	X_7	X_{12}, X_{10}
Y_{14}	X_8, X_{11}	X_{12}, X_{14}, X_{13}	X_1, X_9, X_3	X_{11}, X_7	X_{16}, X_9	X_{10}, X_2	X_{12}	X_3, X_{10}, X_{11}	X_4, X_5, X_{13}	X_6, X_{11}	X_7, X_{15}	X_{12}, X_{14}

Note: EN—extremely negative, N—negative, MN—moderately negative. Source: authors' development

The revealed correlations between X_n variables and Y_n health parameters allowed to test the hypotheses:

Hypothesis 1 (H1): *partly confirmed. Out of the environmental variables $X_{1–6}$, the quality of running water and wastewater treatment have the most positive effect on the reduction of incidence rates of certain infectious and parasitic diseases; neoplasms; diseases of the nervous system; diseases of the skin and subcutaneous tissue; congenital malformations, deformations, and chromosomal abnormalities. Improvement of the access to the quality-assured sources of water decreases incidence rates of endocrine, nutritional, and metabolic diseases; diseases of the circulatory, respiratory, and genitourinary systems; diseases of the musculoskeletal system and connective tissue.*

Hypothesis 2 (H2): *not confirmed. The most negative effect on the public health parameters is caused by the low quality of drinking water and the low percentage of households with running water available in their homes. Economic factors also negatively affect public health. As the economic accessibility of food decreases, nutritional habits of consumers change from high-fat animal products to bread, macaroni products, and low-nutritious starches. Per capita consumption of meat, dairy products, and vegetables is well below both the national average and Russia's national standard of healthy nutrition [115]. In some of the territories, higher values of nutrition variables $X_{7–12}$ correlate with the emergence of the diseases of the nervous system; diseases of the skin and subcutaneous tissue; diseases of the musculoskeletal system and connective tissue; congenital malformations, deformations, and chromosomal abnormalities (all four—increase in X_7); certain infectious and parasitic diseases (increase in X_8). The proportion of market food in the diets is the highest among the territories of the Russian Arctic, but due to low living standards, people cannot afford themselves consuming market foods of high quality. Available vegetables, dairy products, meat, and fish are frozen and with a high content of food preservatives to extend the shelf life.*

Hypothesis 3 (H3): *confirmed. Low income, poverty burden, and a high proportion of food expenditures in households' budgets (economic variables $X_{13–16}$) along with the prevalence of traditional food in the diet exert a negative influence on the majority of Y_n diseases in Type 3 and Type 4 territories. Low diversified meat-based and fish-based diets result in the increase in the incidence rates of diseases of the digestive system, diseases of the skin and subcutaneous tissue, diseases of the musculoskeletal system and connective tissue, and infectious and parasitic diseases. The growth of real value of cash incomes and reduction of the proportion of population living below a minimum subsistence income may allow reducing the incidence rates of the diseases of the circulatory system; congenital malformations, deformations, and chromosomal abnormalities; neoplasms; diseases of the blood and blood-forming organs; certain disorders involving the immune mechanism; endocrine, nutritional, and metabolic diseases.*

4. Discussion

Across Arctic communities, public health outcomes are affected by different combinations of environmental, nutritional, and economic factors. Both the modes and degrees of the influence are determined by a location of a territory, level of industrial development, economic and social situation, and patterns of life and food consumption.

Environmental factors, primarily, air pollution, are commonly recognized as the sources of the most serious toxicological impacts on human health, including respiratory and cardiovascular diseases, neuropsychiatric complications, and cancer [116,117]. In the Russian Arctic, previous studies identified such emissions as sulfate aerosols from metal smelting [118] and flaring associated with oil and gas extraction [119] but found no evidence of direct health implications from air pollutant emissions [2,120]. In this study, the negative influence of air pollution on health parameters was revealed across all types of circumpolar territories. Among the most notable consequences were increased respiratory ailments – the incidence rates of Y_9 were unacceptably high across all four territory types (Table 10). Syurin and Burakova [121] found that the development of respiratory pathology patterns (primarily, chronic bronchitis and chronic obstructive pulmonary disease) was closely associated with the locations of harmful industries in the western part of the Russian Arctic. In those Types 2 and 4 territories, people experienced increasing susceptibility to air irritant agents (X_1 and X_2) and the quality of water supply systems in the cities (X_5 and X_6). This corresponded with the recommendations to improve access to clean water to reduce respiratory morbidity made by Kovesi [122,123]. Miller and Gaudette [124] suggested that a lack of vitamins (particularly, vitamin A) in the diet might be a possible co-factor of higher lung cancer in northern communities, while Tse et al. [125] reported household crowding and living conditions to be significantly associated with respiratory infections among indigenous people. In relation to our findings, it seemed that the adequacy of nutrient intake (X_7 and X_{11}) along with the degree of outdoor physical activities (X_{13}, hunting and fishing) had positive effects on the reduction of Y_9 incidence rate. Other health issues for which a correlation with environmental factors was revealed included eye irritation, increased cardiovascular morbidity, and carcinogenic effect of pollutants. This finding supported earlier results of Li and Mallat [126], Vermaelen and Brusselle [127], and Chen and Kan [8].

Among environmental factors, air pollution was recognized as moderately negative, the most negative being the quality of water and the volume of wastewater discharge. This corresponded with Hennessy et al. [17], Thomas et al. [16], and Wenger et al. [128], who all demonstrated a direct correlation between clean water in sufficient quantities and significant reductions in the occurrence of illness and hospitalizations due to infectious disease. Our finding also supported Nilsson et al. [129], who reported that over one-third of the population in the circumpolar territories of Russia used drinking water from non-centralized sources; Bressler and Hennessy [130], who recognized poor access to safe water among the causes of gastrointestinal illness and water-washed infections, such as respiratory tract infections and skin infections; as well as Daley at al. [131], who associated inadequate domestic water quantities with transmissible diseases and bacterium infections in indigenous communities. According to Hennessy and Bressler [132], the burden of inadequate water and sanitation services on public health is higher among rural and indigenous populations in the Arctic. In contrast with this opinion, our study demonstrated extremely negative health effects of poor water supply systems and water pollution not only in the eastern parts of the Russian Arctic but also in urbanized Type 2 territories and industrialized Type 1 territories. In this part, our results corresponded with the data of Dudarev et al. [133], who discovered that 51% and 19% of water samples taken from the centralized water sources in Type 2 territories did not comply with hygienic norms in terms of chemical and biological contamination, respectively. In the industrialized territories of Type 1, the coverage of households by public water supply exceeds 80%, but the majority of water supply facilities have not been properly repaired, cleaned, and disinfected for a long time [133]. Centralized water sources and drinking water are highly contaminated by chemical and biological agents. In Type 1 and Type 2 territories, water of low quality is delivered through the outdated supply system to the majority of households, which results in the growth of incidence rates of endocrine, nutritional, and metabolic diseases; diseases of the circulatory, digestive, and genitourinary systems; diseases of the musculoskeletal system and connective tissue.

High pollution load increases the level of contamination of wildlife, a premier source of food for indigenous peoples in the Arctic. According to Vinokurova [134], Greaves [135], and Ignateva [136], pollution destabilizes the ecological base of the High North and threatens food and nutrition security. Previously, it was demonstrated that traditional food consumption patterns might benefit various health parameters in indigenous communities [32,77–83,137]. As distinct from these studies, we revealed the negative health impacts of traditional food in some indigenous habitats in Type 3 and 4 territories. This corresponded well with earlier findings of Jeppesen et al. [84], Bjerregaard et al. [85], and Jørgensen et al. [89] that traditional dietary pattern was associated with lower β-cell function and a higher risk of impaired fasting glucose and type 2 diabetes mellitus. It was found that undiversified meat and fish-based diets in Type 3 and Type 4 territories, respectively, correlated with higher incidence rates of endocrine, nutritional, and metabolic diseases and diseases of the circulatory and genitourinary systems.

In the indigenous communities and rural territories of Type 3 and Type 4, diversification of the diets may impact public health in a positive way, but the economic accessibility of market food among rural people is low. Dudarev et al. [36] complained about the prohibitively high cost and limited availability of market food across the Arctic zone of Russia. Wesche and Chan [80], Ford [138], and Guyot et al. [139] found that low levels of income and high food costs resulted in changing diets and neglecting healthy nutrition. Poverty forces people to seek a substitution to the expensive market food in traditional hunting and fishing, but the contribution of traditional economic activities to the improvement of public health is minor. There are economic barriers reported by Lambden et al. [32] and Goldhar et al. [140], such as high costs of hunting and fishing, tightening food sharing networks, and hunting and fishing regulations.

In industrialized and urbanized territories of the Arctic Zone of Russia, on the contrary, we registered the increase in the proportion of market food in the diets, which was in line with the emergence of "nutritional transition" previously conceptualized by Egeland et al. [141] and Kuhnlein et al. [31] in the case of the Canadian Arctic. Young et al. [142] supposed such transition to contribute to an increase in diabetes and other diseases among northerners. Receveur et al. [143] and Nakano et al. [144] recognized an increased consumption of market food as a contributing factor to a higher incidence of overweight and obesity. Our findings demonstrated that in the territories where the proportion of market food in the diets was above the Arctic average, the negative impact of the transition was limited to the increased incidence rates of the diseases of the digestive system, immune diseases, and neoplasms.

5. Conclusions

This study attempted to convey the existing complexity of public health impacts in the case of the Arctic zone of Russia. It was investigated how various factors were interrelated with the incidence rates of major diseases in different types of circumpolar communities. The establishment of the set of environmental, nutritional, and economic variables allowed for a particularly useful analysis of the variations within the groups of health impacts and thus made the levels of exposure to certain diseases comparable across the territories. The territories were grouped in four types based on the respective levels of influencing groups of factors: (1) industrial sites, the most negative health impacts of air and water pollution; (2) urban agglomerations, the most negative health impacts of nutritional factors; (3) inland and (4) coastline indigenous communities, the most negative health impacts of economic factors.

The testing of the three hypotheses resulted in the identification of positive and negative effects on selected health parameters. The relationships between the regressands and corresponding regressors were discovered individually for eight territories of the Arctic Zone of Russia and generalized for the four types of the territories, given the alternations between the highest positive and most negative influences on the dependent variables. In Type 1 and Type 2 territories, poor quality of running water along with low access to the quality-assured sources of water increased the exposure to infectious and parasitic diseases, neoplasms, diseases of the circulatory, respiratory, genitourinary, and nervous systems, and endocrine, nutritional, and metabolic diseases. In Type 3 and Type 4 territories, low diversified diets based on traditional food correlated with the increase in the incidence rates of nutritional and metabolic diseases. Underconsumption of milk and vegetables resulted in a lower intake of vitamins and mineral nutrients, including calcium, phosphorus, magnesium, and zinc. Declining economic accessibility of adequate diets further exacerbated nutrition-related health problems.

The set of environmental, nutritional, and economic variables applied in this study as regressors was open-ended and discussible. The six-stage regression analysis that involved collinearity checks based on the VIF and BSA methods allowed to build regression models in which regressands' variations were well explained by independent variables. However, due to the ongoing environmental, climate, and economic changes in the Arctic, a further focus on finding the most feasible influencing factors of public health could place the issue in the larger context of social-ecological change that is affecting the resilience of the Arctic and health and well-being of its inhabitants. In such respect, further studies of health impacts in the High North should involve comparisons with other Arctic countries except Russia. Effectively addressing emerging health-related challenges require continued research into health risk factors and trends in order to facilitate the identification of priority areas for policy interventions.

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sustainability

Article

The Sustainable Development of Financial Inclusion: How Can Monetary Policy and Economic Fundamental Interact with It Effectively?

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Abstract: It is necessary to analyze the relationship between financial inclusion and circumstances-monetary policy and economic fundamentals, which has a practical reference value for policy makers. This paper studies the impact of the circumstances on financial inclusion factors by using a vector autoregressive method. Empirical results show that monetary policy has a short-term positive impact on financial inclusion factors, while the economic fundamental has the opposite, which means that the positive monetary policy promote the development of financial inclusion in the short term and the sudden change of the economic situation will make it harder. Based on the data of the World Bank and the situation of China, we make an analysis and comparison of the empirical results, and draw two implications: first, the sustainable development of financial inclusion needs a suitable circumstance; second, the appropriate coordination and mutual facilitation of economic fundamentals and finance is conducive to the sustainable development of financial inclusion.

Keywords: financial inclusion; sustainable development; monetary policy; economic fundamental; vector autoregression

1. Introduction

Recently, the development of financial inclusion has attracted attention of the whole world. Financial inclusion means that individuals and businesses have access to useful and affordable financial products and services that meet their needs-transactions, payments, savings, credit and insurance-delivered in a responsible and sustainable way (http://www.worldbank.org/en/topic/financialinclusion/overview). Many countries are committed to promoting the development of financial inclusion based on their own features and advantages. Malaysia, for instance uses "agent banking", which is a hallmark initiative that leverages technology to provide financial services to under-served population, particularly in rural areas [1]. The development of financial inclusion is boosted in China, and the Chinese government regards it as a national policy of development with the two financial payment platforms Alipay and WeChat [2]. However, financial exclusion still exists. According to the new report of the World Bank, close to one-third of adults—1.7 billion are still unbanked in our world and about half of unbanked people include women and poor households in rural areas or out of the workforce (http://www.worldbank.org/en/topic/financialinclusion/overview). Therefore, financial inclusion urgently needs further development. Meanwhile, the sustainability of financial inclusion deserves more attention. A study on the relationship between financial inclusion and its circumstance will contribute to the sustainable development of financial inclusion. For low-income individuals and regions without sufficient financial resources, inclusive finance plays an important role in income growth and industrial upgrading (Bruhn and Love, 2014) [3]. Referring to the Sustainable Development Goals, the goal of sustainable financial inclusion is to provide financial support to vulnerable groups based on equal opportunities, help them reduce poverty, thereby reducing social inequality and achieving stable economic growth (https://www.undp.org/content/undp/en/home/sustainable-development-goals.html). At present, there exists a regional imbalance in the development of China's inclusive finance, and the sustainability of financial inclusion is insufficient (Zhu et al., 2018) [4] It motivates us to seek the favorable environment to promote the sustainable development of China's financial inclusion. The Global Microscope 2018 on Financial Inclusion released by The Economist Intelligence Unit assessed the enabling environment for financial inclusion in 55 countries and five domains were selected by numbers of experts to define the enabling environment (https://www.eiu.com/public/topical_report.aspx?campaignid=Microscope2018). It is in line with our research and the 'circumstance' can be regarded as the specific form of the enabling environment. In the critical periods of developing financial inclusion, this paper discusses two important questions. One is what kind of circumstance is suitable for the development of financial inclusion, the other is how to achieve the sustainable development of financial inclusion.

With the interest of people from all over the world, financial inclusion has become a hot topic in academia.The present research can mainly be divided into two categories. One was to discuss on measuring the financial inclusion index or the level of financial inclusion with country level or zone level data (Sarma, 2008; Adalessossi and Kaya, 2015; Ambarkhane et al., 2016; Kumari, 2017; Wang and Guan, 2017) [5–9]; the other was exploring the correlation between financial inclusion and the development of economic factors or society factors (Naceur and Ghazouani, 2007; Sarma and Pais, 2011; Pearce, 2011; Hassan et al., 2011; Allen et al., 2012; Van der Werff et al., 2013; Pradhan et al., 2016; Boukhatem, 2016; Kim et al., 2018) [10–18]. In particular, Kim et al. (2018) studied the correlation between financial inclusion and economic growth in Organization of Islamic Cooperation (OIC) countries [18]. Sarma and Pais (2011) found that levels of human development and financial inclusion in a country move closely with each other [11]. However, few papers have regarded monetary policy and economic fundamental as the external circumstance of financial inclusion and done research on the response of financial inclusion to these circumstance, let alone how to make sure the sustainability of financial inclusion. In this paper, we observe how financial inclusion interacts with economic fundamental and monetary policy by building the vector autoregressive model (VAR) with Chinese regional data. Firstly, we analyse to what extent the external environment-Chinese monetary policy can influence the factors of financial inclusion; Secondly, the financial inclusion factors' dynamic reactions are discussed for the changing of economic situation; Lastly, we obtain some discoveries of the sustainable development of financial inclusion.

The contribution of this paper is shown below. The first is to empirically analyze how the circumstances influence the financial inclusion and how they interact with each other. The second is to recognize the importance of economic and financial coordinating. Namely, while employing inclusive finance to solve the problem of imbalanced economic development, we should avoid the waste of inclusive financial resources caused by overheated economy. The last is to make recommendations of sustainable development of financial inclusion. The remainder of the paper is designed as follows. In Section 2, we give the literature review on financial inclusion. Section 3 presents an analysis of current situation in China. The data description and model are introduced in Section 4. Empirical results and analyses are shown in Section 5. The last section shows the discussion and conclusions.

2. Literature Review

The report of the World Bank documented that financial inclusion played an important role in keeping financial stability, mitigating social inequality, reducing poverty and so on. In academia, financial inclusion is a hot topic of study, and there are two main aspects for financial inclusion research. One is measuring the index of financial inclusion with different methods or different data sets. The other is documenting the correlation between financial inclusion and economic factors. Additionally, we try to review the existing literature concerned with the relationship between financial inclusion and monetary policy. The last part is a review of related studies on the financial inclusion sustainability. The rest of this section will review articles following the aspects above.

In the measurement of financial inclusion aspects, many scholars devoted themselves to improving the reasonability of measurement. Being similar to the method of constructing Human Development index, Sarma (2008) proposed the index of financial index by banking penetration, availability of banking services and usage all three dimensions with 55 countries data [5]. Chakravarty and Pal (2013) proposed an axiomatic approach to analyze the banking financial inclusion and they suggested geographical penetration and credit availability as two policy targets [19]. Cámara and Tuesta (2014) relied on demand and supply-side information to measure the extent of financial inclusion at country level for eighty-two developed and less-developed countries [20]. With Global Findex Database, Adalessossi and Kaya (2015) measured the degree of financial inclusion in the African countries [6]. They found out of the 41 total countries 27 had a low level in financial inclusion whereas 14 had a high level. Kumari (2017) used an empirical study of financial inclusion in urban poor of Kolkata [8] and it revealed that urban poor's financial untouchability prevailed uniformly in all the regions of Kolkata irrespective of the economic development of the region. Except for the regular factors of index, Ambarkhane et al. (2016) considered financial services such as by NBFCs, Insurance Companies, Pension Schemes into the measurement of financial inclusion [7]. Wang and Guan (2017) measured the level of financial inclusion across countries by using the index of financial inclusion and the World Bank Global Findex database [9]. They revealed a geographical spatial aggregation distribution in which developed European and North American countries enjoyed higher levels of financial inclusion than the less developed countries of Africa and most of Asia.

The significance of developing financial inclusion focuses on its effect for the development of our society. Naceur and Ghazouani (2007) revealed that there was no significant relationship between banking and stock market development and growth with an unbalanced panel data from 11 Middle Eastern and North African countries [10]. Sarma and Pais (2011) examined the relationship between financial inclusion and development by empirically identifying country-specific factors that were associated with the level of financial inclusion. It was found that levels of human development and financial inclusion in a country were closely related [11]. The policies targeted to promote inclusion were rather effective among the most excluded (Allen, 2012) [14]. Hassan et al. (2011) provided evidence on the role of financial development in accounting for economic growth in low- and middle-income countries classified by geographic regions [13]. Yu et al. (2012) provided evidence on the role of financial development and stock market development in accounting for economic growth across geographic regions and income groups [21]. Van der Werff et al. (2013) found that social factors were an important part of highly banked populations in a set of thirty-one countries from the OECD [15]. Higher levels of trust in government and formal financial institutions increased the level of financial inclusion. Increases in income inequality were predicted to decrease the banked population within a nation. Allen et al. (2014) employed regression analysis to examine the level and variation of financial development and financial inclusion across Sub-Saharan Africa and the rest of the developing world, relying on some basic determinants and found that population density is considerably more important for financial development and inclusion in Africa than elsewhere [22]. Park and Mercado (2015) constructed a financial inclusion indicator to assess various macroeconomic and country-specific factors affecting the financial inclusion of 37 developing Asian economies. They found that in developing Asia, per capita income, rule of law, and population size increase financial inclusion, while age dependency ratio lowers financial inclusion [23]. Pradhan et al. (2016) investigated the Granger causal relationships between insurance market penetration, broad money, stock-market capitalization, and economic growth, using panel data for the association of south east asian nations regional forum countries for the 1988–2012 period [16]. Boukhatem (2016) identified the channels through which financial development affected poverty. Their results suggested the important contribution of financial development to the reduction of poverty [17]. Kim et al. (2018) examined the relationship between financial inclusion and economic growth in Organization of Islamic Cooperation countries. They concluded that financial inclusion had a positive effect on the economic growth in Organization of Islamic Cooperation countries [14]. Banerjee et al. (2018) studied the impact of institutional financial inclusion on per capita real GDP growth of selected six South Asian countries [24].

There is limited literature investigating the relationship between financial inclusion and monetary policy, and most of them focus on the monetary policy reaction of the growing financial inclusion. Mbutor and Uba (2013) used annual data from 2005–2014 to examine the impact of financial inclusion on monetary policy effectiveness in Africa and supported the notion that deepening financial inclusion would effectuates monetary policy via working with commercial banks' lending rates with the empirical results [25]. Mehrotra and Yetman (2014) noted that enhancing financial inclusion can somehow cause the declination of output volatility and inflation volatility, which is connected with setting the optimal monetary policy [26]. Evans O. (2016) modeled the the impact of financial inclusion in Africa and found that financial inclusion is not a significant motivation of monetary policy effectiveness while monetary policy effectiveness promotes financial inclusion [27]. Lenka and Bairwa (2016) conducted a study of SAARC countries and it indicated that if the financial accessibility (financial inclusion) increases, it may decrease the inflation rate in an economy, which presents a positive relationship between financial inclusion and monetary policy [28].

The systematic theoretical framework on the sustainability of financial inclusion development has not established yet. Some researchers propose key factors of financial inclusion sustainability, which can back up our study. Erkut B. (2016a) stated that the competitive advantages can be used to classify countries since the stage of competitiveness is closely related to the effectiveness of governmental institutions [29]. Erkut B. (2016b) conducted a further study which illustrated that the same tendencies existed between entrepreneurship and innovation based on a balanced collection of objective and subjective data [30]. Similar principles apply to the financial inclusion sustainability. A single financial institution ought to be facilitated with more financial inclusion for the entrepreneurial scene and gaining new competitive advantages to maintain its sustainability. Zhu et al. (2018) asserted that it is a good way to evaluate the sustainability by measuring the balance of financial inclusion [4]. Social networks can help informal financial inclusion fully and partially guard against systematic risks from the institutional environment (Chai et al., 2018) [31]. It can be learned that strengthening the effects of social networks may help to promote financial inclusion sustainability.

Though some papers documented the correlation between financial inclusion and economic growth (or poverty, income inequality, etc.), few papers considered the impact of the circumstance on financial inclusion. This paper makes up for the deficiency and discusses the sensibility of financial inclusion to its developing circumstance. Also, we document the importance of economy and finance coordinating.

3. Current Situation of Financial Inclusion in China

In recent years, the People's Bank of China has incentivized financial service providers to expand credit services for under-served segments through various policies, including differentiated reserve ratios, loan refinancing, and rediscounted loans and so on. By the end of 2016, the reserve ratio for rural commercial banks registered in county areas was 12 percent, and the reserve ratio for rural cooperative banks, rural credit cooperatives, and village and township banks was 9 percent. These ratios are 5 percentage points and 8 percentage points lower, respectively, than the reserve ratio for large commercial banks. In order to support financial institutions to develop inclusive financial services, the People's Bank of China issued a total of RMB 439 billion (US$66 billion) in refinancing in 2016, and a total of RMB 381 billion (US$57 billion) was re-discounted (http://documents.worldbank.org/curated/en/181081518452447434/). These monetary policies encourage financial institutions to increase credit supply in specific field by lowering interest rates and loosening borrowing requirements to enable rural areas, the poor, and small and micro enterprises to have access to financial services. Under the implementation of these monetary policies, the agriculture related loans and small and micro enterprise loans have indeed significantly increased in quantity. Since the five-year Plan to promote financial inclusion was formulated, China has documented many monetary policies related to financial inclusion. In addition, these policies have greatly promoted the development of financial inclusion (Figure 1, there is a large change in green vertical line).

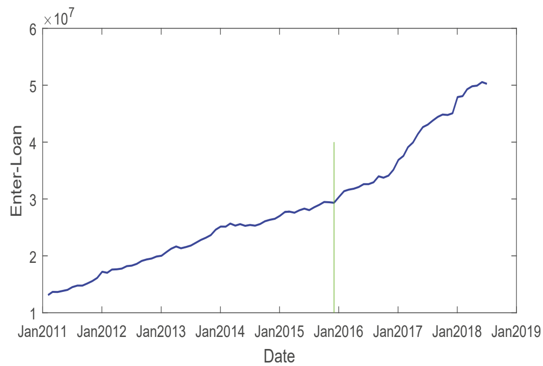

Figure 1. The Enter-Loan graph (Unit: 10,000 Yuan). The blue line shows the total amount of Enter-Loan and the green line documents the points that China formulates a Plan to promote financial inclusion development (2016–2020).

According to the World Bank's Global Findex DataBase in 2011, 2014 and 2017 (https://globalfindex.worldbank.org/), the account penetration rate and debit card holding rate of China are always higher than the world average and the average level of upper middle income countries with an upward trend. This reflects a progress in improving the coverage of basic financial services. In terms of credit availability, although the proportion of people who borrowed from financial institutions has achieved steady growth under the implementation of various monetary policies, there is still a certain gap compared with the average level of upper-middle-income countries and even world average. As a matter of fact, financial inclusion has reached a certain level in scale, and its quality and capital efficiency must be taken seriously, which is closely linked to its sustainable development.

Under the downward pressure of GDP growth, China is facing the problem of sustainable economic growth. Although China is the world's second largest economy, the situation of uneven development still exists. It is found that economic disparity exists between regions and provinces in China, and the disparity has a negative impact on economic growth (Lee et al., 2012) [32]. Many low-income people in rural areas are excluded from the growth of the economy while cities and developed areas tend to gather more resources and receive preferential treatment from the financial system. As a result, financial exclusion makes these people fall behind the development of society even more. More attention should be paid to solve the problem of uneven distribution of financial resources to further achieve the sustainable economic development.

China has entered a new economic normality of structural adjustment, regional balanced development and industrial upgrading. Under the macroeconomic background of economic restructuring, it is necessary to solve the financial structural problems so that poor and backward regions can obtain financial resources for industrial upgrading, thereby stimulating the growth potential of the county economy and the agriculture (Peng and Hu, 2018) [33]. Because of that, financial inclusion has been put forward to deal with financial structure optimization and economic sustainable development issues in a way of relocating financial resources and exploiting the developing potential in those less-developed area. As we can see from Figure 2, the level of inclusive financial development in China generally lags behind that in high-income countries, and even lower than the world average in some respects. This shows that China's financial inclusion is insufficient and its role in balancing economic growth is limited. In fact, the Chinese government has actively adopted a broad range of policy measures such as monetary and credit policies, tax policies, and supervision policies to promote finance to keep pace with economic development. These policies have made great progress, but there is still a long way to go in China for achieving sustainable and long-term financial inclusion because of the existing imbalanced distribution of financial resources.

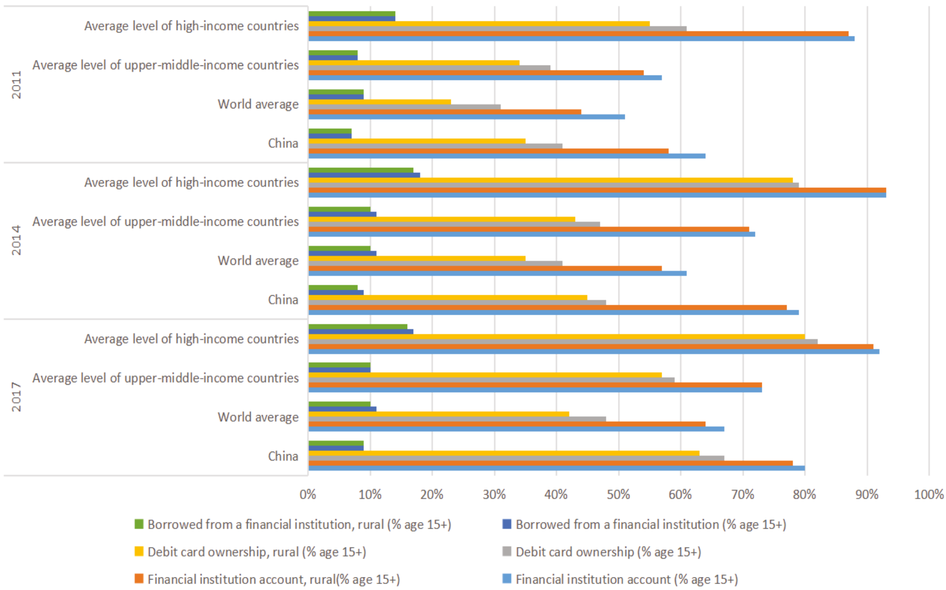

Figure 2. International comparisons of financial inclusion. World Bank's Global Findex DataBase.

4. Methodology and Materials

4.1. Vector Autoregression Model

This paper aims to empirically examine the impact of the circumstance to financial inclusion by establishing a two-variable VAR model. The traditional econometric method relies only on economic theory to describe the relationship between variables, and cannot provide a strict explanation of their dynamic shock effect. In addition, it also needs to consider modeling the hysteresis function of all endogenous variables for each endogenous variable in the system (Liu and Xia, 2018) [34]. Therefore, it is very complicated to analyze economic problems with time series using traditional econometric methods. The VAR model constructs the model by using each endogenous variable in the system as a function of the hysteresis of all endogenous variables in the system. The model is not based on economic theory and does not distinguish between internal and external variables in advance. In this way, it can effectively control the complexity and difficulty of model estimation and analysis.

The general expression of the VAR model is as follows (Lütkepohl, 2005) [35]:

$$Y_t = B_1 Y_{t-1} + B_2 Y_{t-2} + \cdots + B_p Y_{t-p} + \epsilon_t,$$

where Y_t is an n-dimensional variable vector; B_t is the relevant coefficient matrix to be evaluated; p and t are the lag order and time, respectively; and ϵ_t is the random disturbance term.

4.2. Impulse Response Function

To observe the actions of financial inclusion factors to some changes of circumstance, this study makes the impulse response function (IRF) to characterize and verify correlation between the variables. The IRF expresses the influence of the current and future impact of a standard deviation of random disturbance terms on all endogenous variables of the model. IRF can clearly and intuitively describe the dynamic reaction process of each endogenous variable to its own change or that of other variables.

IRF is shown as (Hamilton, 1994) [36]:

$$I_Y(n, \delta, \omega_{t-1}) = E[Y_{t+n}|\epsilon_t = \delta, \epsilon_{t+1} = 0, \ldots, \epsilon_{t+n} = 0, \omega_{t-1}]$$
$$-E[Y_{t+n}|\epsilon_t = 0, \epsilon_{t+1} = 0, \ldots, \epsilon_{t+n} = 0, \omega_{t-1}].$$

where n is the impact response period, δ refers to the impact from variables, ω_{t-1} represents all the available information when an impact occurs, I_Y is the impulse response value of the n-th period.

4.3. Variable Selection

In general, monetary policy tools can be summarized into two types: price tools and quantity tools. Price tools are mainly through price guidance to play the role of interest corridor, price leverage, stabilization of expectations and financing costs, and then indirectly regulate economic operation. Quantity tools mainly play the role of monetary instruments in regulating the liquidity of the banking system and expanding the aggregate demand through the adjustment of the quantity of money supply, and then directly affect the economic operation (Liu and Xie, 2016) [37]. Many authors selected the Fed Funds rate and money supply (M2) as the proxy variable of price tools and quantity tools, respectively [38–40]. However, there is not a Fed Funds rate in China, the seven-day weighted interbank lending rate (Inter-Lend) is usually selected as proxy variable of price tools. We follow their study and select the Inter-Lend and M2 as the proxy variable of monetary policy. The aim of financial inclusion is to make vulnerable groups to obtain the service of finance. The rural population is about 540 million in China, which is the main service object of financial inclusion. So, we choose the agriculture related loan (Agri-Loan) and agricultural enterprise loan of all financial institutions (Enter-Loan) in Hunan province as the proxy variable of financial inclusion factors (Hunan is a province which lies in the central China). GDP reflects the overall economic strength of the country and is a good proxy variable of economy. Thus, GDP is selected as the proxy variable of economy in this paper. Many scholars have studied the relationship between oil and economy, which found that there was a strong correlation between them [41,42]. To keep the robustness of results, the oil price is selected as another proxy variable of economy. China's economic development is vulnerable to the world oil price fluctuations. We thus choose the crude oil price of West Texas Intermediate (Oil Price) as the proxy variables of the world oil price. The data of interbank lending rate and M2 comes from the People's Bank of China. The financial inclusion factors data gather from Changsha central sub-branch of People's Bank of China. The data of GDP comes from national bureau of statistics in China. WTI is downloaded in U.S. Energy Information Administration.

5. Empirical Results and Analysis

The purpose of this paper is to document the sensitivity of financial inclusion factor to circumstance-monetary policy and economic fundamental. So we discuss it separately in terms of monetary policy and economic fundamental. All the models are two-dimensional VAR. For data availability, the model on monetary policy and economic fundamental uses monthly data and quarterly data, respectively.

5.1. Monetary Policy

5.1.1. Data Processing

We regard all the drawn data normalization and its characteristic of volatility is shown in Figure 3. To avoid the occurrence of pseudo-regression before building VAR model, we need test the stationarity of data by Augmented Dickey-Fuller (ADF) test and the results are described in Table 1.

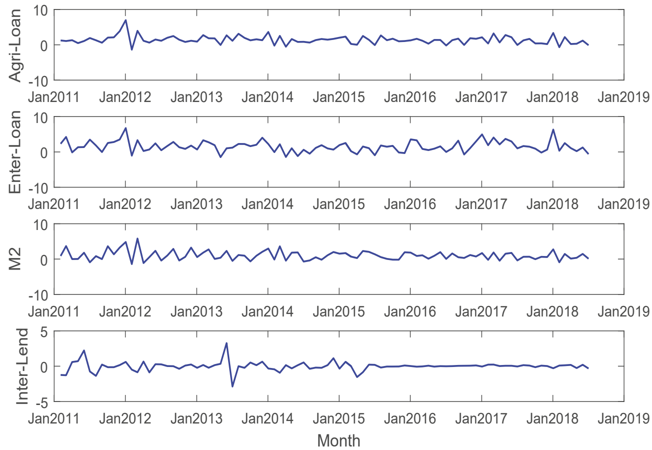

Figure 3. The characteristic of volatility on related variables (Month).

Table 1. The results of ADF test (Month).

	Agri-Loan	**Enter-Loan**	**M2**	**Inter-Lend**
Value	−4.56 *** (0.01)	−3.33 * (0.07)	−6.10 *** (0.01)	−7.39 *** (0.01)

The numbers in brackets are *p* value. *, ** and *** indicate the 10%, 5% and 1% significance level, respectively.

5.1.2. Impulse Response Analysis

To figure out the relationship between variables clearly, we document four 2-dimensional VAR models, which are Agri-Loan to M2, Agri-Loan to Inter-Lend, Enter-Loan to M2 and Enter-Loan to Inter-Lend. The optimal lag order of four VAR models is determined by Akaike information criterion and its values are shown in Table 2.

Table 2. The optimal lag order.

	Agri-Loan-M2	**Agri-Loan-Inter-Lend**	**Enter-Loan-M2**	**Enter-Loan-Inter-Lend**
Value	2	3	2	4

Figure 4 depicts the impulse response of four VAR models (Here, because we only consider the response of financial inclusion factors to monetary policy in this paper, we give the one-way impulse response.). The four graphs of Figure 4 all show that monetary policy has a short-term positive impact on financial inclusion factors and after a period of fluctuation, they all gradually fade away. The shapes of Figure 4a,c are similar, which shows the price tools of monetary policy are not flexible to the use of fund. Compared with Figure 4b,d, the responses of financial inclusion factors are different faced to shock of the Inter-Lend, and it shows the use of money of financial inclusion are more sensitive to quantity tools of monetary policy. It can be found that either price or quantity tools of monetary policy have a positive effect on financial inclusion. The positive incentives of quantity tools of monetary policy are more capable of promoting the development of financial inclusion compared with price tools.

To sum up, monetary policies produce positive influence on financial inclusion although the effect is limited and differs between quantity and price tools. The policymakers should pay more attention to the effectiveness and sustainability when implementing tools for financial inclusion. Combining quantity tools with price tools could be a more effective and applicable solution under the background of financial structural adjustment, which provides a sustainable circumstance for financial inclusion growth.

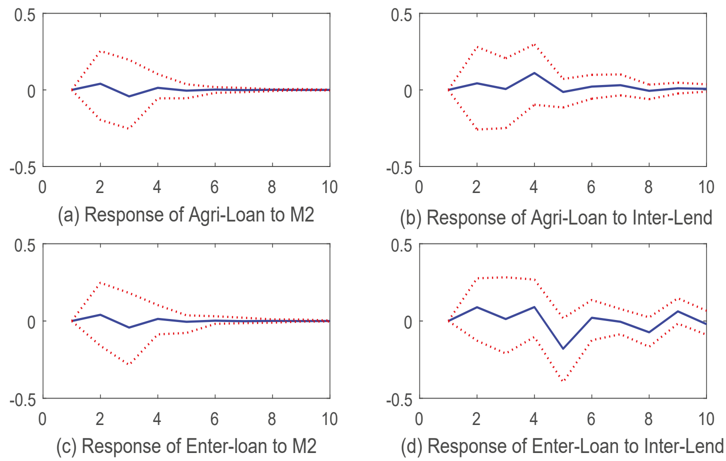

Figure 4. Impulse response graph.

5.2. Economic Fundamental

5.2.1. Data Processing

Same as above, we regard all the drawn data normalized and its characteristic of volatility is in Figure 5. We use the method of augmented Dickey-Fuller (ADF) test to identify the data stationarity. (There are some differences compared in Section 5.1. For the quarterly data existing obvious seasonality, we need go further difference for normalized data) and the results of ADF test are shown in Table 3.

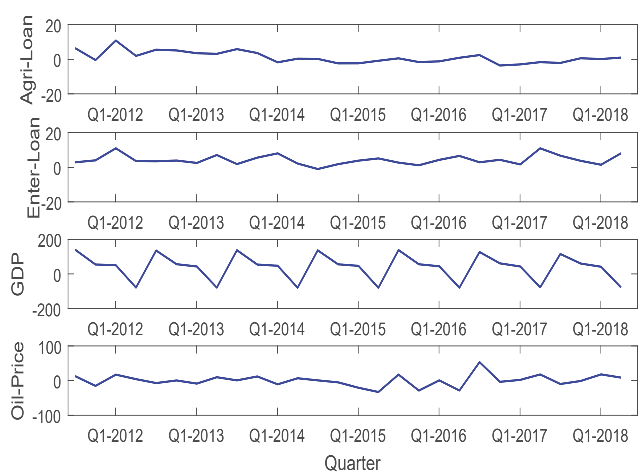

Figure 5. The characteristic of volatility on related variables (Quarter).

Table 3. The results of ADF test (Quarter).

	Agri-Loan	Enter-Loan	GDP	Oil Price
Value	−4.93 *** (0.01)	−5.52 * (0.01)	−30.9 *** (0.01)	−5.02 *** (0.01)

The numbers in brackets are *p* value. *, ** and *** indicate the 10%, 5% and 1% significance level, respectively.

5.2.2. Impulse Response Analysis

Similar with monetary policy, we also document four 2-dimensional VAR models, and they are Agri-LoanG to GDP, Agri-Loan to Oil Price, Enter-Loan to GDP and Enter-Loan to Oil Price. The optimal lag order of four VAR models is determined by Akaike information criterion and the values are described in Table 4.

Table 4. The optimal lag order.

	Agri-Loan-GDP	Agri-Loan-Oil Price	Enter-Loan-GDP	Enter-Loan-Oil Price
Value	3	2	1	2

Figure 6 gives the results of the impulse response of four VAR models. The four graphs of Figure 6 all show that economic fundamental has a short-term negative effect on financial inclusion factors and they all gradually fade away after a period of fluctuation. Specifically, the shapes of Figure 6a,c are similar, which shows the Agri-Loan is not sensitive to the shock of GDP, but the Enter-Loan displays sensitivity faced to the shock of GDP. Compared with Figure 6b,d, the responses of financial inclusion factors are similar faced to shock of the oil price, and it shows the oil prices have an impact on financial inclusion factor. This unexpected negative shock indicates that the financial and economic development of the sample area is not coordinated, and there is no mutual promotion between the two. The empirical results can be analyzed with the present economic and financial situation in China. With the slowdown of China's GDP growth, industrial upgrading and structural adjustment have become a new direction of economic development. Inclusive finance needs to keep up with the pace of the economy by contributing to the industry development and improving the intrinsic capability of the underdeveloped regions, so as to achieve coordinated development with the economy.

The negative effects shown in the empirical results can be divided into two cases. On one hand, since the financial inclusion cannot catch up with the pace of GDP and even suppress its growth in the long term. The government must take forceful measures to allocate the financial resources rationally and promote more fund to the financial inclusion sector, especially in rural and county areas where the financial inclusion should focus on. At the same time, financial inclusion as a specific form of financial liberalization can have a positive cumulative effect on the economy (Peng et al., 2014) [43]. On the other hand, high development of financial inclusion without a good economy is not sustainable. It must make full use of the role of finance in economic development and commit themselves to developing the economy, so that financial resources can be effectively used. In summary, the economy can have a good interaction with the financial inclusion by way of economy and finance coordinating.

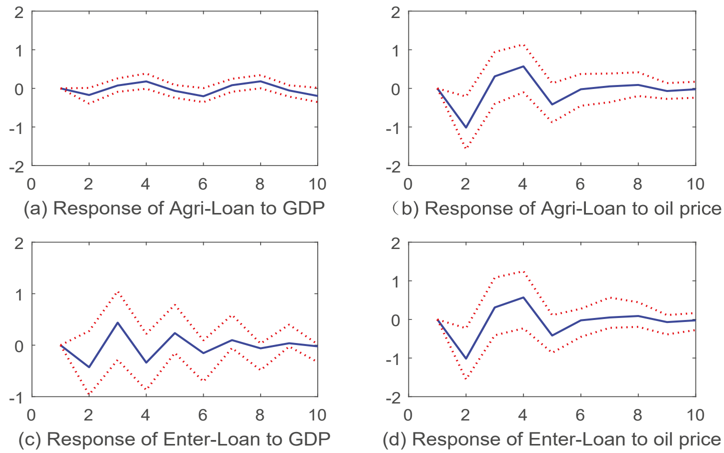

Figure 6. Impulse response graph.

6. Discussion and Conclusions

In this paper, we document the behaviors of financial inclusion factors under the impact of their circumstance-monetary policy and economic fundamental. Many countries are advocating for developing financial inclusion, but every country has his own circumstance. Our work has rich policy implications. The policy makers and regulators will be able to adjust the strategy of financial inclusion without delay when noticing the sensitivity of financial inclusion to the circumstances. Therefore, investigating the developing circumstance of financial inclusion is of real value to itself, especially to its sustainability.

Many researchers focused on the measuring the status of financial inclusion, namely measuring financial inclusion index (Sarma, 2008; Adalessossi and Kaya, 2015; Allen et al., 2012, etc.) [5,6,14]. However, accurate measurement of the status financial inclusion is only the first step of studying financial inclusion, and the next step is how to achieve the effective development of financial inclusion and make it sustainable. At the same time, some other researchers study the responses of economic variables or society factors to financial inclusion. However, exploring the behaviors of financial inclusion is of equal importance under the shock of circumstance (Ageme et al., 2018; Lawal et al., 2018; Fontin et al., 2019; Ghosh, 2019; Lashiitew et al., 2019) [44–48]. It can provide references for policy making by understanding and further optimizing the circumstance of financial inclusion. Also, the structural similarity among innovation-driven economies- intellectual property legislation, infrastructure and well-functioned government is worth taking into consideration (Erkut B., 2016a) [30]. The structural similarity is in tune with our consideration when it comes to the circumstances of improving the productivity and effectiveness of financial inclusion.

Based on the regional data of China, we established eight VAR models. The first four are for monetary policy, and the last four are for economic fundamental. The empirical results show that the monetary policy exists a positive impact on the factors of financial inclusion and the economy has a contrary one. From the empirical results, it is found that financial inclusion reacts differently in response to the shock of circumstances and we further gain two following discoveries.

Firstly, the sustainable development of financial inclusion needs good circumstances (effective monetary policy). The People's Bank of China has implemented multiple incentive policies which can encourage financial service providers to expand credit to underserved segments. Financial service providers that demonstrate higher outreach to these groups receive better access to these facilities. Therefore, financial institutions have more incentives to provide loans for groups such as farmers, the poor, and small and micro enterprises. Our empirical results that monetary policy has a positive impact on financial inclusion keep with the monetary policy intentions. A good policy environment is essential to the sustainable development of financial inclusion. Policy makers should introduce incentive monetary policies for inclusive finance and adjust them in a timely manner to maintain the sustainable usefulness of these monetary policies.

Secondly, the economy and finance coordinating is of great importance, which means the mutual promotion of economy and finance. The pursuit of excessive GDP growth is likely to incur structural economic problems, i.e., the imbalance of regional economic development, which will adversely affect the sustainable development of financial inclusion [4]. This imbalance will lead to the polarization of the rich and the poor, and from a financial perspective, it is reflected in the uneven distribution of financial resources. In view of this, the Chinese government is taking a series of measures to eliminate this imbalance, a process known as 'structural reform'. This process requires coordination between finances and the economy. Inclusive finance should serve the balanced development of the economy, especially in rural areas. Furthermore, sustainable inclusive finance will enable vulnerable groups to participate in the process of industrialization, and provide financial support for the transformation and upgrading of underdeveloped regions and local industries.

In the significant transition period of financial inclusion, our research confirms and analyzes the characteristics of this period, and also provides some ideas for the sustainable development of financial inclusion from the environmental aspect. To sum up, the circumstances-incentive monetary policy and economy coordinating with finance are the important prerequisites for the sustainable development of financial inclusion, because the circumstances can promote the quality and capital efficiency of financial inclusion and realize long-term coordinated development of financial inclusion. Then, it can be turned into a virtuous circle, for sustainable financial inclusion will lay a solid foundation for future development. Also, there are a few limitations to our paper. For the data availability we only selected two financial inclusion factors and chose China as the object of study because of data restrictions. So we hope to gather more related data on this topic for further research.

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Article

Management Accounting Change as a Sustainable Economic Development Strategy during Pre-Recession and Recession Periods: Evidence from Russia

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Abstract: The volatility of both global and national markets has emerged in recent years. In response to the changes in the operating environment, organizations have been adopting various practices to ensure sustainable development by anticipating threats and managing risks. While many studies are focusing on the investigation of strategic adaptation to the volatile economic environment, there has been little research examining management accounting (MA) as a sustainable development strategy in times of economic turbulence. This study investigates the degree of variation in the use of MA practices induced by economic recession. Investigating the variations in management accounting practices in Russian organizations in 2000–2013 (pre-recession period) and 2014–2018 (economic recession), the authors explore the change across 54 MA tools split into operation, management, and strategy pillars. The contribution of this study to the literature involves the understanding of the use of particular MA tools across various types of organizations and industries before and during the economic recession, as well as discovering the intention to change the instruments in case the economic situation deteriorates. The survey of four types of organizations (micro, small, medium, and large) in five sectors (service, industry, trade, agriculture, and tourism) was conducted in seven territories of Russia differentiated on the level of their economic performance (well-performing, average, and declining). The survey revealed that, during the crisis, the respondents tend to drop using many of proactive sustainability-oriented MA tools and instead focused on achieving immediate and direct effects on sales, profits, and other performance parameters by employing less-sophisticated short-term MA instruments. The forecast of future application of MA tools in a falling economy revealed that, in an attempt to achieve durable and sustainable performance, the organizations of all types and sectors intended to focus on practices such as risk management variance analysis, rolling forecasts, payback, breakeven analysis, and activity-based management.

Keywords: economic crisis; management accounting; management decision making; recession; survey; sustainable economic development

1. Introduction

In recent decades, the global economic environment has become increasingly volatile. Instability affects all countries, all sectors, and all types of businesses [1]. In such conditions, the ability of an organization to anticipate and respond to external fluctuations is critical for its survival [2]. So far, the majority of the existing studies have focused on the investigation of how volatility-induced economic slowdowns and recessions might be responded to using strategy-related instruments, i.e., strategic planning, mapping, and management. In depressed macroeconomic conditions, firms encounter a stronger pressure to operate in a sustainable way and become increasingly transparent about sustainability-related management accounting (MA) practices they implement [3]. External pressures induce internal fluctuations, both of which are important factors of sustainability integration within corporate strategy amid economic decline. George et al. [4] found such amalgamation of external influences and internal responses as one of the enablers of change in MA practices. External pressures are prevalent in shaping management decision-making in relation to accounting, reporting, and control, while integration of sustainability-related accounting tools into performance management systems leads to better management and control of sustainability performance in business [4].

Accounting techniques, nevertheless, have received less attention as these are considered less related to any organizational changes and reporting on sustainability performance. However, the development of existing management accounting techniques along with the emergence of new MA tools have enabled the organizations with a possibility to focus on not only financial information but also non-financial issues and thus to provide a strategic scope to sustainability management decisions. Specifically, sustainability management accounting (SMA) and sustainability reporting (SR) have integrated performance measurement accounting tools which communicate the information about how a firm acts to improve its economic effectiveness and efficiency. Transforming the economic environment imposes the need for adaptation of MA practices to respond to the changing conditions of the markets, the behavior of competitors and consumers, economic policies of the government, and other factors [5]. The effectiveness of management decisions is increasingly determined by the ability of a firm to generate qualitative information about the actions it has taken, results achieved in terms of economic and social sustainability, and the need to improve internal business processes [6]. In a volatile economic environment, firms increasingly rely on SMA and SR as comprehensive processes of the collection, analysis, and communication of sustainability-related information [7].

Although the research in the field of SMA and SR has been on the agenda for several decades already, the empirical evidence has been mainly based on case studies [8,9] most of which captured MA practices in developed countries. Few of them have analyzed the adoption of MA tools in more vulnerable economic environments in developing countries and even fewer have ever addressed the practices of management accounting in Russia. In the beginning of the 1990s, Russia started reforming its accounting and reporting system to converge it with the International Financial Reporting Standards (IFRS). The adoption of the IFRS has led to a significant revision of accounting methodology [10] and resulted in financial performance of the Russian companies [11] during the 2000s. In 2014, the Russian economy was hit by sanctions and rapidly falling oil prices. These shocks led to a significant balance of payment pressures with a surge in capital outflows and depreciating exchange rate [12]. Since that time, Russia has been experiencing economic decline further dampened by the intensification of geopolitical tensions. Very few studies, however, have investigated the effects of economic volatilities on the changes in the application of MA practices in the Russian organizations after 2014. Due to the fact that, in the course of over two decades of the reform, Russia has not fully adjusted its national accounting and reporting system to the IFRS, the findings of international studies cannot be fully employed to reflect and explain de facto reactions of Russian companies on the change of economic situation in the country. The limitations in the application of the IFRS in Russia are related to the national peculiarities of application of professional judgment and the specific approach to the interpretation of economic events [11]. Technically, in many companies, financial statements are still drawn up in accordance with the Russian system of accounting which in turn is being transformed to the IFRS framework "with due account for the specific circumstances and the analysis of encountered problems" [13]. Beyond the technical aspects of management accounting, engaging with sustainability accounting in Russia poses a challenge of understanding how the application of particular MA tools can contribute to improving performance of a firm and ensuring its resistance to the volatilities of the external economic environment.

The purpose of this study is to contribute to the understanding of the MA change induced by economic recession and the way in which it can lead to the changes in sustainability performance of the firms. The paper is structured as follows. In Section 2, the authors overview major studies related to the topic of the paper and develop a narrative around the relationships between economic recession, sustainability, and the ways in which the firms can respond to external volatilities of economic environment by using various MA tools. The approach adopted in investigating the above research questions is presented in Section 3. In Section 4, this study involves the survey of the four types of organizations in various industries in Russia about the use of MA tools in the pre-recession period of 2000–2013, the change in 2014–2018 as a response to economic decline, and the intentions to adopt MA practices in case the economic situation deteriorates. In Section 5, the authors' findings are discussed in relation to the prior literature along the three pillars of management accounting, economic volatility, and sustainable development. In Section 6, the authors summarize all findings, implications, and contributions, as well as refer to the limitations of the study and point out future research directions.

2. Literature Review

A review of the prior literature allows two streams of accounting–sustainability-narrative to be revealed. On the one hand, the contribution of MA to sustainable development has been questioned from a point of view of the critical social accounting perspective, particularly, by Gray [14] and Zvezdov [9]. On the other hand, in some sources, specifically, in the works of Burritt and Schaltegger [15], Siti-Nabiha and Scapens [16], and Schaltegger and Burritt [17], a management approach to accounting supports sustainability management, while SMA and SR are recognized among the contributors to measuring and managing sustainability performance.

A number of studies have established a theoretical background for the idea that management accounting tools can serve an active role in improving sustainability performance, supporting managerial decisions, and shaping organizational changes [18–20]. Celik [21] observed that companies could ensure sustainability by employing proper accounting practices prior to and pursuant to the economic crisis. Many other studies have been devoted to solving general theoretical, methodologic, and methodological aspects of management accounting as one of the tools of sustainable performance [22–27], particularly, the model of management accounting based on the ideas of organizational control and efficiency [28]; various aspects of setting the system of budgeting in an enterprise [2,29,30]; the concept of the balanced scorecard [31–34]; the role of communication in the decision-making system based on management accounting [35]; the role of management accounting in the development of performance evaluation systems [36]; issues of genesis and prospects for further development of management accounting [37–42].

Many of the previous studies have examined the factors influencing SMA and SR. Adams and McNicholas [43] studied SR in relation to accountability and organizational change and identified the impediments to the development of SR framework and its integration into planning and decision making. Gond et al. [44] developed a research framework that delineated a set of possible relationships between sustainability issues, management accounting, reporting, control, and organizational strategy, while Caputo et al. [45] investigated how traditional and new MA tools and management control systems may be integrated into different sustainability strategies and thus affect organizational changes. George et al. [4] studied the role of accounting technologies, specifically performance management and reporting systems, in supporting sustainability integration into strategic operations across various types of organizations and recognized management accounting as one of the effective sustainability embedding mechanisms. It is worth mentioning the works devoted to the problems of transformational processes of accounting and analytical support for the management of economic entities [46–53]. The formation of the concept of the enterprise business model under the influence of macroeconomic factors was completed by Magretta [54]; the description of inflation accounting methods was performed by Davis-Friday and Rivera [55], Konchitchki [56] and Robson [57]; trajectories of management accounting development were investigated by Luft and Shields [58]; the transformation of managers information needs was studied by Anderson and Lanen [59]; new planning and control mechanisms in managerial accounting were investigated by Chenhall and Langfield-Smith [36].

While previous studies have discussed the role of management accounting and performance management systems in supporting sustainability, few of them have captured the organizational responses to economic recessions. Much of the literature in the area of accounting–sustainability relationships has examined the factors of and motivations for SMA without proper reference to the internal organizational context, notwithstanding that a volatile economic environment imposes a significant effect on the performance of the firms at not only macro but also micro levels [43,60]. Economic, financial, and, particularly, accounting footprints of sustainability are unclearly expressed and thus rarely used [61], which calls for the need to adapt management methods to unstable conditions and, accordingly, requires the development of new, more effective methods for generating information and making proper managerial decisions in the times of economic transformation. In the beginning of the 2000s, Adams [62], Larrinaga-Gonzalez et al. [63], and O'Dwyer [64,65] were among the first to study the internal accounting and reporting processes through the lenses of their impact on organizational change. In continuation of their studies, Mat et al. [66] assessed the level of employment of various MA practices in response to the changing business environment, including rapid developments in information and communication technology, development of computer-based production systems, and integration of smaller firms into larger ones. Van der Stede [67] offered reflections on opportunities and challenges for management accounting research in the wake of the financial crisis and discussed a continuing need to study incentives, risk management, and budgeting.

In Russia, despite the extreme volatilities of the economic environment during the 1990s and adverse effects of the economic crisis of 2008–2009 on business, few studies have addressed accounting practices through a prism of sustainable development. A description of separate methodical approaches to management accounting in the conditions of the economic crisis may be found in Bobryshev et al. [68], Truhachev et al. [69], and Yakubiv [70]. On the back of recession in Russia, sustainability-related MA research has been attracting increasing scholarly attention, but its focus is on the macro level, whereas a limited attention has been paid to the role of MA instruments in supporting sustainability within organizations at the micro level. Litvin et al. [71] examined the problem of the differentiation of territories at the macro level under the influence of crisis factors. Elchaninova et al. [72] and Gerasimov et al. [73] studied the ways of balanced development of socio-economic systems in the context of crisis processes in the Russian economy. Despite the emerging consideration of MA effects on sustainable operation of a firm in the conditions of economic crisis, there are questions that still remain unanswered. First, which particular effects economic recession imposes on the application of MA tools. Second, how exactly MA practices may contribute to the improvement of economic sustainability of a firm in the volatile environment. Third, in Russia, less is understood of the de-facto MA practices within organizations and how they are transforming over the period of economic decline.

Another problem in understanding the true relationship between accounting practices and sustainability is endogeneity of influencing factors. Managerial decisions are typically determined by a set of external and internal factors, the causality of which increases when exposed to the volatilities of the external economic environment. Different choices in organizational behavior are linked to one another, but change in various manners in response to the environmental changes [74]. So far, there have been many studies addressing the endogeneity problem in relation to management accounting. Chenhall and Moers [75] provided an overview and discussion of endogeneity as well as possible solutions to the problem. Li [76] attempted to summarize econometric methods that are commonly used to address endogeneity concerns and illustrated how generalized method of moments, instrumental variables, fixed effects models, lagged independent variables, and control variables could be used to mitigate the endogeneity problem. Coles et al. [77] addressed the endogeneity concerns through the lens of firm performance and external uncertainties and their influence on industry pay gap. Abdallah et al. [78] presented the case studies and provided the insights into how endogeneity may be controlled in empirical analysis. To the best of the authors' knowledge, none of the previous studies have addressed the endogeneity problem in relation to management accounting in Russia.

3. Materials and Methods

Previous studies have equipped organizations with a range of tools to measure their performance and decide on strategic directions of development in various economic conditions. To reveal an extent to which business has settled on the currently available set of tools or is searching for alternative solutions to ensure sustainability in the times of economic decline, the authors utilized a six-question survey consisting of two parts.

In part one (questions 1–3), at the beginning of the survey, a question was asked whether or not the respondent represented a company located in one of the regions included in the study. To reflect the complexity of economic recession effects, seven territories of Russia were included in the survey: well-performing—those >10% above the national average rate of growth (Moscow city and Krasnodar region), average—within ±10% corridor around the national average rate of growth (Kaluga and Kaliningrad), and declining—those >10% below the national average rate of growth (Stavropol, Arkhangelsk, and Khabarovsk regions).

In question 2, the respondents were asked if the company operated in one of the sectors included in the survey. According to Coles et al. [77], in different sectors, industry performance risk influences firm performance risk and sustainability in various extents. Through financial policy, increasing risk can generate uncertain performance. The higher the volatility in the market, the more uncertainty there is about winning the competition. Better growth opportunities in a particular sector result in higher performance and stability but lead to an increase in the expected value of performance gap between sectors. To provide cross-sectoral comparisons of the recession-induced changes in application of MA tools, the study included service sector (professional, financial, and other types of services) (particularly developed in Moscow city), industry sector (Kaluga, Arkhangelsk, and Khabarovsk regions), retail and trade (Moscow city and Kaliningrad region), agricultural production (Stavropol, Krasnodar, and Khabarovsk regions), and hospitality and tourism (Stavropol and Krasnodar regions).

Qualifying questions 1 and 2 were intended to ensure that a respondent was aligned with the proposed sample group. The questionnaires received from the territories or sectors not included in the survey were removed from the sample. To send the questionnaires and collect responses from the respondents, the authors used the SurveyMonkey platform. The invitations to complete the survey (information about the purpose of the study, description of the content, and a link to the SurveyMonkey page) were emailed to 358 potential respondents—accounting specialists, operational managers, and senior managers of the private companies located in the selected territories and operating in the selected sectors. Contact details of the companies and responsible employees were obtained from the Catalogue of Russian Enterprises [79]. Its interface allows the use of filters and selection of organizations across various sectors in all territories of Russia. Of the completed questionnaires, 166 were received, 153 of which were qualified for the study.

In question 3, the respondents were asked about the size of the company. The coefficients of firm size measures are robust in sign and statistical significance, that is why we considered size as the key variable which affects all the variables included in our study. Frank and Goyal [80], Rajan and Zingales [81], and Moeller et al. [82] all reported that firm size affected the empirical results in the sphere of corporate finance. As demonstrated by Dang et al. [83], the most popular firm size proxies used in empirical studies are total assets, total sales, and market value of equity. In Russia, however, all the three parameters relate to the commercially sensitive information. Therefore, we did not expect the respondents to disclose the commercial data in the questionnaires and instead used the number of employees suggested by Dang et al. [83] and Hart and Oulton [84] as an alternative firm size measure when the main measures were not available or irrelevant. The cut-off for the classification was based on the Federal Law of the Russian Federation "On the Development of Small and Medium-Sized Entrepreneurship in the Russian Federation" [85]. Out of 153 qualified, there were 21 micro organizations (below 15 employees), 67 small-sized firms (15–100 employees), 36 medium-sized companies (101–250 employees), and 29 large enterprises (over 251 employees).

In part 2 (questions 4–6), it was suggested that the respondents select the MA tools commonly utilized in their companies in the pre-recession period of 2010–2013 (question 4) and the period of economic recession in 2014–2018 (question 5). Lastly, in question 6, the respondents were asked which MA tools their companies would continue using (or the new ones they would adopt) to improve sustainability as the economic situation deteriorated. The MA tools were split into three pillars and ten categories (Table 1), it was suggested that the respondents select up to three tools per category.

Table 1. Management accounting tools included in the survey.

Pillar	Category	Tool	Abbreviation
Operation	Cost	Costing for Jobs	CJ
		Full Costing	FC
		Marginal Costing	MC
		Overhead Allocation	OA
		Standard Costing	SC
		Variance Analysis	VA
	Price	Cost-Plus Pricing	CPP
		Market-Sensitive Pricing	MSP
		Segmental Pricing	SP
		Price Skimming	PS
		Penetration Pricing	PP
	Budget	Cash Forecasts	CF
		Financial Year Forecasts	FYF
		Flexible Budgeting	FB
		Incremental Budgeting	IB
		Rolling Forecasts	RF
		Zero-Based Budgeting	ZBB
	Profitability	Breakeven Analysis	BA
		Customer Profitability Analysis	CPA
		Economic Value to Customer	EVC
		Product/Service Profitability Analysis	PPA
		Relevant Costing for Decisions	RCD
	Investment	Internal Rate of Return	IRR
		Net Present Value	NPV
		Non-Financial Issues	NFI
		Payback	P
		Post Completion Audits	PCA
		Sensitivity Analysis	SA
Management	Performance measurement	Cash Flow Return on Investment	CFRI
		Economic Value Added	EVA
		Profit Before Tax	PBT
		Residual Income	RI
		Return on Capital Employed	RCE
	Performance management	Activity-Based Management	ABM
		Balanced Scorecard	BS
		Business Process Re-Engineering	BPRE
		Total Performance Scorecard	TPS
		Value-Based Management	VBM
		Six Sigma	SS
	Reward	Exclusive Incentive Schemes	EIS
		Management Incentive Schemes	MIS
		Profit Sharing Schemes	PSS
		Share Options	SO

Table 1. *Cont.*

Pillar	Category	Tool	Abbreviation
Strategy	Performance reporting	Contribution after Variable Costs	CVC
		Gross Margin after Full Costs of Sales	GMFCS
		Net Profit Margin after Allocation of Overhead	NPMAO
		Segment Contribution after Attributable Costs	SCAC
		Value-Added Reporting	VAR
	Strategic techniques	Competitor Analysis	CA
		Core Competencies	CC
		Risk Management	RM
		Strategy Mapping	SM
		SWOT Analysis	SWOT
		Value Chain Analysis	VCA

Source: authors' development.

The selection of the MA tools and their distribution along the pillars and categories was based on the recommendations of the Chartered Institute of Management Accountants (CIMA) [86]. Operation pillar included the tasks demanded by the organization, specifically, costing of activities, pricing of products, analysis of profitability of revenue-generating activities, and allocation of available assets by means of budgeting and investment. The management pillar was concerned with how economic performance was measured and which tools were applied to manage it in the conditions of economic recession. The reactions of the respondents to the economic environment were then mediated by strategy pillar tools in two directions: first, reporting to senior management, stakeholders, and a wide audience, and, second, affecting strategic decision making.

The application of the survey method revealed the patterns and features of the transformation of management accounting in Russia under the influence of the economic downturn. It also allowed establishing new approaches to management accounting in response to the deteriorating economic environment, as well as discovering explicit and hidden factors that promoted and hindered the development of management accounting in a country which experienced an economic recession.

4. Results

On average, respondents use by and large between two and three major tools in each of the categories surveyed. Among operation pillar MA tools, the most widely used ones were variance analysis (VA; cost category), cost-plus pricing (CPP; price category), financial year forecasts (FYF; budget category), product/service profitability analysis (PPA; profitability category), and net present value (NPV; investment category) (Figure 1).

In most of the categories, a current set of tools is different from that used in the pre-recession period of 2010–2013. Among cost tools, respondents lean toward such flexible and adaptive instruments as variance analysis and overhead allocation over standard and full costing. As the purchasing power of population deteriorates, market-sensitive pricing is gaining ground as the second most widely used tool in the pricing category in favor of segmental pricing and price skimming. In the budget category, business abandoned the common FYF tool and increasingly focused on rolling forecasts (RF), incremental budgeting (IB) and flexible budgeting (FB). It reflects the tendency of using those budgeting techniques which provide greater and tighter control and oversight of expenditure in the conditions of budgetary constraints. Among profitability analysis tools, there was still high overall level of interest in PPA, but it decreased as those companies which face economic troubles get concerned about breakeven analysis and seek custom-oriented approaches.

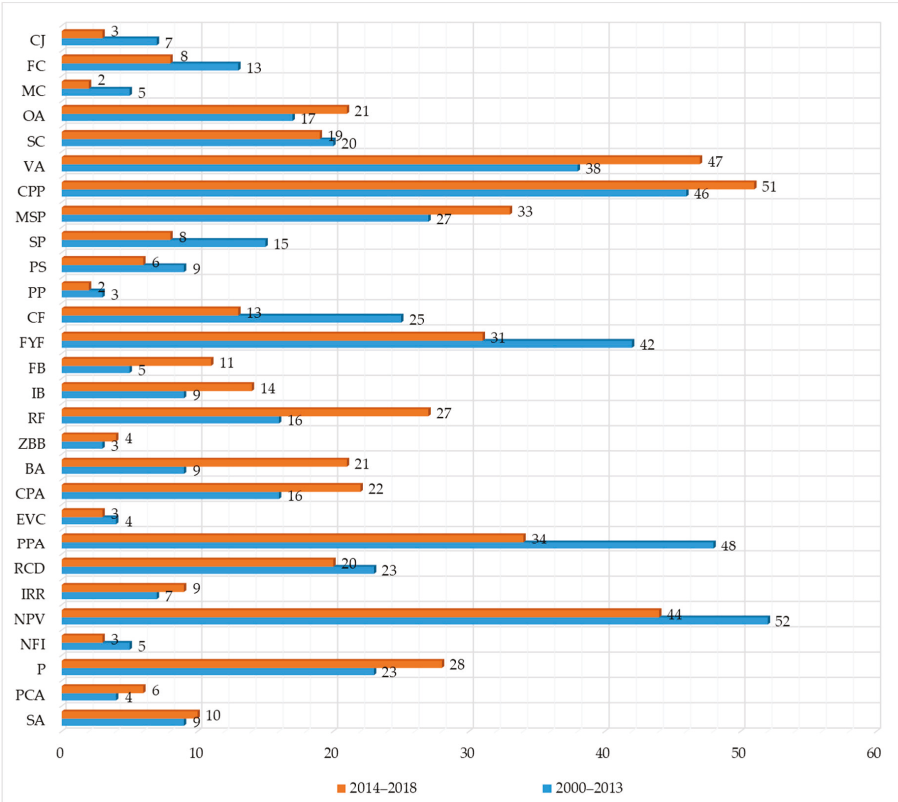

Figure 1. Management accounting tools: operation pillar, percentage of respondents. Source: authors' development.

The surveyed organizations reported on the growing concern of profit and cash flow returns as the two critical performance measurements in the times of economic recession (Figure 2). When it comes to the use of performance management tools, activity-based management (ABM) gains widespread attention due to its orientation on current activities of an organization and responsiveness, the two characteristics crucial in the vulnerable economic environment. Among reward tools, responsiveness stipulated the emergence of profit-sharing schemes in favor of exclusive incentive schemes (EIS) and management incentive schemes (MIS) as profit sharing schemes (PSS) allowed the establishment of a direct and immediate link between performance and reward.

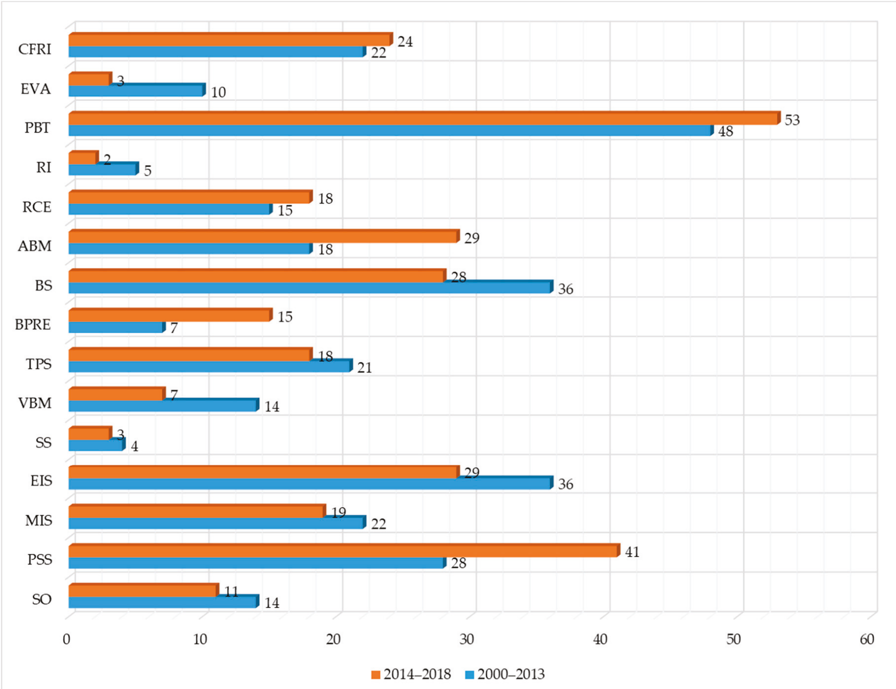

Figure 2. Management accounting tools: management pillar, percentage of respondents. Source: authors' development.

Very largely because of a similar reason, the advantages of direct tools in the conditions of economic changes conditioned the emergence of reaction-based short-term instruments in favor of pro-action long-term oriented strategic approaches. In the pre-recession period, respondents used a combination of measures to develop and manage their strategies, including strategic mapping, value chain analysis, Strengths-Weaknesses-Opportunities-Threats analysis (SWOT), and other future-looking management techniques (Figure 3). The economic downturn, however, made strategic planning less applicable compared to immediate reactions and thus prompted the relevance of risk management tools and analysis of competitors.

The tendency of switching to short-term tools over strategic planning was particularly prominent in, the territories in which the pace of economic growth is below the Russia's average (Arkhangelsk, Khabarovsk, and Stavropol). In well-performing territories, over 55% of respondents either continued using strategic mapping as the major strategic technique or increasingly employed competitor analysis, but did not entirely shift their focus to managing short-term risks (Table 2).

There was also a significant distinction of declining territories in terms of using RF as the major budgeting tool. In Moscow city, Kaluga, Krasnodar, Stavropol, and Kaliningrad regions, most of the respondents did not report considerable changes in using FYF as the major budget category tool. In Khabarovsk and Archangelsk regions, quite the reverse, many organizations acknowledged RF as the most appropriate tool to control expenditures.

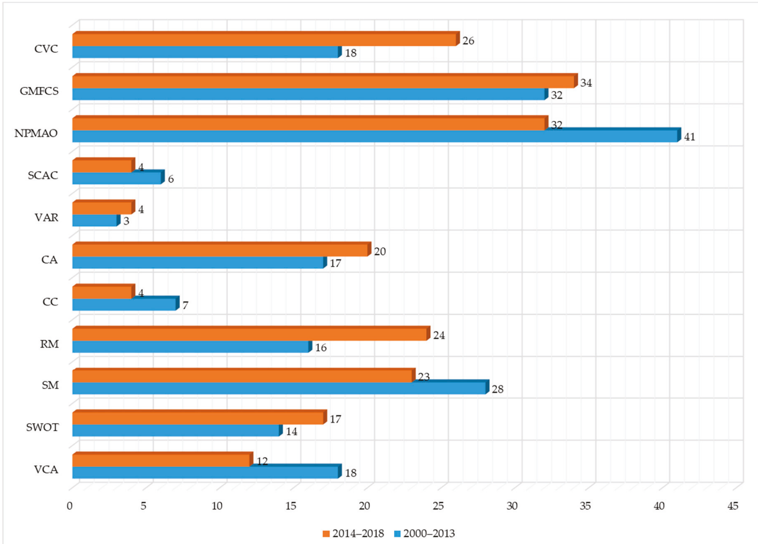

Figure 3. Management accounting tools: strategy pillar, percentage of respondents. Source: authors' development.

Table 2. Survey results: economic performance.

Category	2000–2013			2014–2018		
	Well Performing	Average	Declining	Well Performing	Average	Declining
Cost	VA OA SC	OA VA SC	SC FC VA	VA OA SC	VA OA SC	VA SC FC
Price	CPP SP PS	CPP MSP SP	MSP CPP SP	CPP SP MSP	MSP CPP SP	CPP MSP SP
Budget	FYF CF RF	FYF CF RF	FYF RF IB	FYF CF RF	FYF RF FB	RF IB FB
Profitability	PPA RCD CPA	PPA CPA RCD	PPA RCD BA	PPA CPA RCD	CPA PPA BA	BA RCD PPA
Investment	NPV P SA	NPV P NFI	NPV P IRR	NPV P SA	NPV P IRR	P NPV PCA
Performance measurement	PBT CFRI EVA	PBT CFRI RCE	PBT CFRI RCE	PBT CFRI RCE	PBT CFRI RCE	PBT CFRI RCE
Performance management	BS VBM TPS	BS TPS VBM	TPS BS ABM	BS ABM TPS	TPS BPRE ABM	ABM BPRE BS
Rewards	EIS MIS SO	MIS PSS EIS	PSS MIS EIS	MIS EIS PSS	PSS MIS EIS	PSS MIS EIS
Performance reporting	NPMAO GMFCS CVC	NPMAO GMFCS CVC	GMFCS CVC NPMAO	NPMAO GMFCS CVC	GMFCS NPMAO CVC	CVC GMFCS NPMAO
Strategic techniques	SM CA VCA	CA SWOT SM	SWOT RM CA	CA SM RM	SWOT CA RM	RM CA SWOT

Source: authors' development. Note: top three tools per category and period.

Another finding is that, in declining territories, the economic recession has induced many organizations to change over to payback instead of NPV as the investment category tool. Among the investment-related management accounting tools, payback (P) is the least sophisticated and crudest appraisal technique, which, however, gains importance in the times of economic decline, when businesses seek early payback instead of unsecured long-term investment.

The survey allowed the discovery of the variation in the employment of MA tools between the sectors, particularly, between the service sector and manufacturing. There are tools which usage varied significantly by sector—categories of price, budget, rewards, among others (Table 3). This might reflect a more flexible approach to pricing, budgeting, and situational management in the service sector compared to the industry, as price comparison is much harder for clients who use services than for customers who buy products [86]. When market shrinks because of declining purchasing power of population, service sector seems comparatively keener on adopting new pricing tools, especially demonstrating the interest in market sensitive pricing and segmental pricing. Conservative sectors such as industrial production and agriculture appeared to be less responsive to economic transformations in terms of management accounting, as well as more reluctant to introducing new practices in response to the changes in the economic environment. In the times of recession, organizations in the service sector, trade, and tourism tend to prioritize short-term profit and cash inflow over long-term investment and thus increasingly employ profit sharing schemes and activity-based management practices to ensure immediate inflows.

Table 3. Survey results: sector.

Category	2000–2013					2014–2018				
	Service	**Industry**	**Trade**	**Agriculture**	**Tourism**	**Service**	**Industry**	**Trade**	**Agriculture**	**Tourism**
Cost	VA OA SC	OA VA MC	FC MC VA	FC SC VA	FC VA CJ	VA FC SC	VA OA CJ	VA FC OA	VA FC SC	VA SC FC
Price	SP MSP PP	MSP SP PP	CPP SP PS	CPP MSP SP	SP PP CPP	MSP SP CPP	MSP SP CPP	CPP MSP SP	CPP MSP SP	MSP SP CPP
Budget	FYF CF FB	FYF CF RF	CF FB FYF	FYF CF RF	FB CF FYF	CF FB ZBB	FYF CF IB	CF FB ZBB	FYF CF IB	FB CF ZBB
Profitability	CPA PPA EVC	PPA RCD BA	CPA PPA RCD	PPA BA RCD	BA CPA EVC	PPA CPA BA	PPA BA RCD	BA CPA PPA	PPA BA RCD	BA CPA PPA
Investment	NPV P NFI	NPV SA P	NPV P SA	NPV P IRR	NPV NFI P	P NPV PCA	NPV P IRR	P NPV PCA	NPV P IRR	P NPV IRR
Performance measurement	PBT CFRI RCE	PBT RCE CFRI	PBT RCE EVA	PBT CFRI RCE	PBT RCE CFRI	PBT CFRI RCE	PBT CFRI RCE	PBT RCE CFRI	PBT RCE CFRI	PBT CFRI RCE
Performance management	BS ABM TPS	BS TPS VBM	BS TPS ABM	BS TPS VBM	BS TPS VBM	ABM TPS BS	TPS BS BPRE	ABM BS TPS	TPS BS ABM	ABM TPS BS
Rewards	MIS PSS EIS	EIS MIS SO	PSS MIS EIS	MIS EIS PSS	MIS PSS EIS	PSS MIS EIS	MIS PSS EIS	PSS MIS EIS	MIS PSS EIS	PSS MIS EIS
Performance reporting	NPMAO GMFCS SCAC	NPMAO GMFCS VAR	NPMAO GMFCS SCAC	NPMAO GMFCS CVC	NPMAO GMFCS SCAC	GMFCS NPMAO CVC	NPMAO CVC GMFCS	GMFCS NPMAO CVC	NPMAO CVC GMFCS	GMFCS NPMAO CVC
Strategic techniques	SM CA SWOT	SM CA VCA	SWOT CA SM	SM CC CA	SM CA SWOT	CA SWOT RM	CA SWOT SM	RM SWOT CA	CA RM SWOT	CA SWOT RM

Source: authors' development. Note: top three tools per category and period.

Looking at firm size, it is observed that the organizations of all sizes rely on market sensitive pricing (MSP), CPP, or segmental pricing (SP) pricing tools (Table 4). Micro organizations did not change pricing tools amid the economic downturn of 2014–2018, while medium and large businesses expanded practicing segmental and marketing sensitive pricing in an attempt to react on declining purchasing ability of population and offer affordable pricing solutions to diverse target groups of customers. Some management accounting tools, however, are more resource intensive compared to pricing, and this may explain the relative reluctance of smaller organizations to implement certain tools. For example, in the pre-recession period, FYF was the most popular budgeting tool overall. As the economic recession expanded, the owners of smaller organizations stressed on personal control of resources and expenditures and thus decreased using budgeting tools.

Table 4. Survey results: size.

Category	2000–2013				2014–2018			
	Micro	Small	Medium	Large	Micro	Small	Medium	Large
Cost	SC VA FC	VA OA SC	OA CJ VA	VA OA CJ	VA OA MC	VA OA FC	VA OA MC	VA SC OA
Price	MSP CPP SP	MSP CPP SP	CPP MSP PS	CPP PS PP	MSP CPP SP	CPP MSP SP	CPP MSP SP	CPP MSP SP
Budget	FYF RF IB	FYF CF RF	FYF CF RF	FYF CF ZBB	CF FB FYF	CF FYF FB	FYF CF FB	FYF CF IB
Profitability	PPA RCD BA	PPA RCD BA	PPA CPA RCD	PPA BA EVC	BA PPA RCD	BA PPA CPA	CPA BA PPA	CPA PPA BA
Investment	NPV P IRR	NPV P IRR	NPV P SA	NPV SA NFI	NPV P PCA	NPV P PCA	NPV P IRR	NPV P SA
Performance measurement	PBT CFRI RCE	PBT CFRI RCE	PBT RCE CFRI	PBT RCE EVA	PBT CFRI RCE	PBT CFRI RCE	PBT CFRI RCE	PBT RCE CFRI
Performance management	TPS VBM ABM	BS TPS VBM	BS BPRE ABM	BS ABM BPRE	ABM TPS BPRE	ABM TPS VBM	BS BPRE TPS	BS ABM BPRE
Rewards	PSS MIS EIS	MIS EIS PSS	MIS PSS SO	EIS MIS SO	PSS MIS EIS	PSS MIS EIS	MIS PSS EIS	MIS EIS PSS
Performance reporting	GMFCS CVC NPMAO	GMFCS CVC NPMAO	GMFCS CVC NPMAO	GMFCS NPMAO VAR	CVC NPMAO GMFCS	CVC NPMAO GMFCS	GMFCS NPMAO CVC	GMFCS NPMAO CVC
Strategic techniques	CA SWOT RM	CA SWOT SM	SM CA VCA	SM CC CA	RM CA SWOT	RM SWOT CA	CA SM SWOT	CA RM SWOT

Source: authors' development. Note: top three tools per category and period.

Profitability category is another case where the recession-induced change is observed as organization size increases. In 2010–2013, there was high overall level of interest in PPA, customer profitability analysis (CPA), and relevant costing for decisions (RCD). In 2014–2018, micro and small organizations hurled all their efforts into ensuring breakeven income, while medium and large ones focused on investigating customer profitability to diversify their offers and adopt pricing schemes to new expectations and purchasing behavior patterns. The smaller–larger difference was also marked in strategic techniques category. Among micro and small organizations, 64% of respondents reported the increased use of risk management tools in the times of recession, while medium and large organizations paid more attention to the detailed analysis of competitors.

Overall, in 2014–2018, both small and large businesses shifted from strategic tools (strategy mapping (SM), core competencies (CC), and value chain analysis (VCA)) to situational measures of management accounting. About 28% of respondents (both small and large) expected the use of risk management (RM) to grow in response to deteriorating economic conditions (Figure 4).

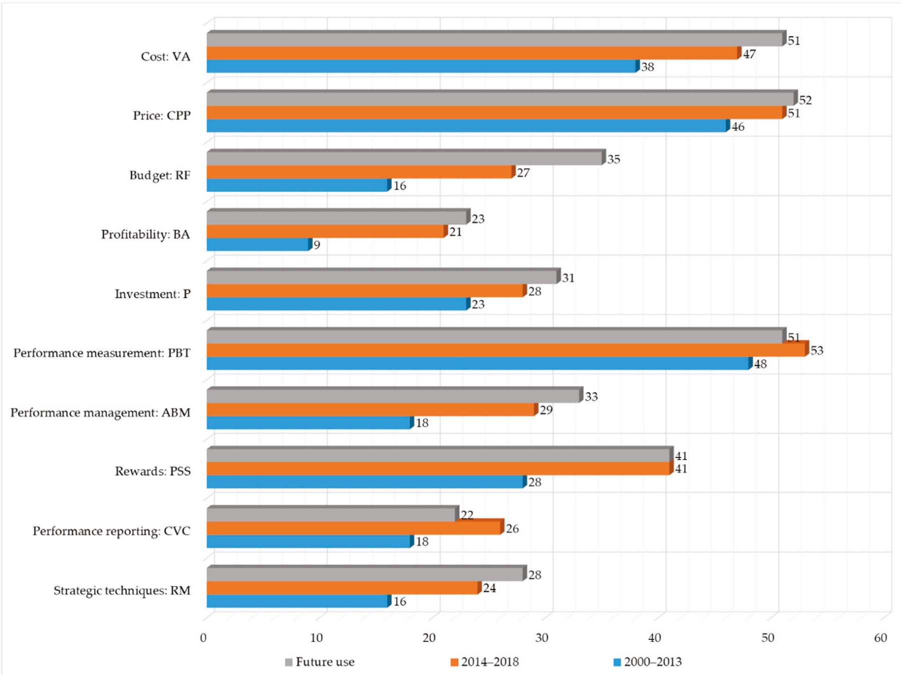

Figure 4. Management accounting tools which organizations intend to adopt in response to the deterioration of economic conditions, percentage of respondents. Source: authors' development.

Along with RM, variance analysis, rolling forecasts, payback, breakeven analysis, and activity-based management were the tools that most respondents intended to use in the next years if the declining trend in the economy continues. It is observable across all sizes of organizations, industry sectors, and territories included in the survey.

5. Discussion

Providing the results of an exploratory study of how accounting can be used to facilitate strategic change, this paper responds to the calls from many authors and organizations regarding the challenges and opportunities of application of management accounting practices in the times of economic downturn. The findings obtained in this paper are generally comparable to those of specialists at the international level. Thus, CIMA [86] shows the increasingly widespread use of management accounting technologies such as rolling forecasts, strategic management accounting, total quality management, balanced scorecard, a model of economic value added, among others. Based on the results of the evaluation of various tools, the most widely used costing tool (production accounting tool) is overhead allocation, as well as variance analysis; they are actively used in the foreign practice of standard costing and full (absorption) costing [86].

Our analysis, however, has revealed that during 2010–2018, the organizations of all sizes, sectors, and types of territories responded to the deterioration of economic situation by changing the management accounting practices. This supports the findings of many studies related to crisis–accounting relationship, particularly, Bangara's [87] view that increase in the volatility of internal and external environments surrounding an organization has an impact on the adoption of management accounting practices, Endenich's [88] assertion that economic crisis represents a crucial driver of management accounting change, Van der Stede's [67] and Edogbanya's [89] appraisal of the impact of economic recession on control mechanisms and their role in the correction of the effects of economic decline in corporate performance, and Simons' [90] finding that the transformation of strategic priorities in the times of economic uncertainties influences the manner in which accounting controls are used.

Senior and Swailes [91] identified the external environment as the second most important aspect of an organization's environment that might cause change (temporal and internal environment being the first and the third, respectively). In the case of the economic decline in Russia, however, the primacy of external environment in transforming accounting practices has been revealed. It supports the concept of the prevalence of external pressures as the causes of change within organizations in the conditions of crisis discussed by Carruthers [92], Greenwood et al. [93], and Tracey et al. [94]. Busco et al. [95] and Moll and Hoque [96] also reported that changes in the application of MA tools occurred as a response to external sources, such as market pressures and consumer expectations.

In correlation with Siska [97] and Abo-Alazm Mohamed [98] who performed their studies in the cases of the Czech Republic and Egypt, respectively, the analysis demonstrated that in the pre-recession period, Russian organizations predominantly used strategy techniques, such as strategic management, budgeting tools, and decision support systems. Higgins and Coffey [99] also showed that, in the times of economic growth, the companies used SR strategically, while sustainability was embedded into their strategic priorities. In the conditions of economic slowdown, Russian organization have switched to short-term tools which have a direct effect on performance parameters. Limited forward-looking as a reaction to increasing external volatility along with quantitative disclosure of operations to achieve sustainability outcomes have been also disclosed by Stacchezzini et al. [6]. Our study demonstrates that the economic decline in Russia in 2014–2018 increased the importance and usage of short-term planning and the development of yearly budgets for cost controlling, performance evaluation, and planning day-to-day operations. In support of the findings of Stacchezzini et al [6], we found that the majority of respondents did not adhere to long-term solutions amid the volatile external environment, abandoned development of long-term action plans and forecasting, and avoided providing information about their sustainability performance, especially when their economic results were poor. This finding conflicts with the results of the surveys conducted by Bennett et al. [7]. They allowed envisaging the increasing use of sustainability information for planning in daily operations among the number of leading companies in Germany and the UK. In those countries, the tendency towards decision situations which require short-term information can be explained in terms of their implications for conventional management accounting. In Russia, many of SMA and SR measures are still new and therefore are not considered to be applicable in short-term decision making. Pavlatos and Kostakis [5] surveyed the organization in post-crisis Greece and ranked strategy, budgeting techniques, and strategic management accounting tools as the highest in importance. As contrasted to our study, their results demonstrated that during the crisis, strategic and planning tools were used more extensively by companies as compared to the period before the crisis [5]. At the same time, on the contrary, the results of our study support the earlier findings of Pavlatos and Kostakis [5] as they revealed a focus on strategy-oriented practices among Greek companies during the pre-recession period, similar to that identified in Russia.

The lags in changing MA practices from those strategically oriented to short-term ones are supposed to be one of the factors of endogeneity in this study. Li [76] suggested lagged dependent variable as one of the methods to reflect observable and unobservable past information of a firm and in such a way to explain its future performance. Each of the three scenarios of pre-recession, current, and future use of MA instruments considered in our study have an endogeneity problem not only because of the endogenous choice of MA tools for the survey but also because of the reverse causality from economic performance to external volatilities. It is supposed that both past performance and current MA practices may have a positive impact on sustainability. The performance expectations are not reflected, particularly, in the variations in MA responses between the firms that foresee better or worse performance under the influence of economic recession. In terms of the lagged managerial decisions, the endogeneity problem has been also discussed by Gatchev et al. [100] in the case of financial decisions and Bae et al. [101] and Lemmon et al. [102] in the case of lagged and future leverages. Abdallah et al. [78] suggest that the endogeneity problem may be mitigated by the utilization of system generalized method of moments in the form of lagged differences in organizational behavior. This method may apply to the scenarios we depicted as it relies on a sufficiently long time series and allows for the inclusion of time-invariant binary variables.

Another dimension of the endogeneity problem in this study is that the goals of management accounting in Russia do not necessarily correspond to global trends in accounting. According to the estimations of the respondents, management accounting has received a predominantly fragmentary distribution in Russia (53.8% of respondents confirmed the off-system use of its single instruments), which does not indicate the full functioning of the management accounting system. Some practices, rather commonly used internationally, such as shareholder value analysis and product lifecycle analysis, have gained in importance and usage in Russia neither in the pre-crisis period nor during the crisis. Abdel-Kader and Luther [103] and Chenhall and Langfield-Smith [104] also reported rare use of such tools, but only for pre-crisis periods. The endogeneity increases in the times of economic decline when the managers have to act quickly and choose strategies and tools of accounting without proper investigation of their effects with the expectation that they will ensure better performance and improve sustainability of a firm. This effect, previously studied by Hamilton and Nickerson [105], is evident among the Russian companies in 2014–2018. This may be explained by the fact that the existence of new MA practices is not widely known about and practiced among the accountants' community in Russia. On the contrary, some tools are widely and even increasingly (in the times of a crisis) used in Russia despite their discontinued use in international practice. For example, CIMA [86] recognized payback as an unsuitable mean of investment appraisal, yet its popularity in Russia has been increasing since 2014 despite the availability of other simple alternatives which provide more informative results.

A significant difference is observed in the target of accounting (in Russian practice, conservative views on the purpose of management accounting prevail). As the economy declined in 2014–2018, the main goal for the majority of the organizations was to minimize costs (17%) and control the performance of the organization in short and medium run (13%). This tendency is particularly observed in underperforming territories among small and medium enterprises in service, tourism, and trade sectors. Budgeting is an area where, for example, CIMA [86] suggested that traditional practices had become outdated and thus predicted the emergence of the tendency for budgets to trigger game-playing, budget-padding, and other sub-optimal behavior. Our study, however, demonstrates that, in the conditions of economic uncertainties, businesses avoid a radical re-invention of budgeting and performance management and continue using rolling forecasts, cash forecasts, and financial year forecasts. It is consistent with the results of Pavlatos and Kostakis [5] who demonstrated that those budgeting tools which allowed tighter control, such as budgeting for controlling costs, gained in importance and use during the crisis, and the findings of Hyvonen [106] who considered budgeting techniques as important and widely used by management in cost controlling and planning in the times of progressing economic decline. Dekan [1] also concluded that in the times of economic recession, the companies tended to reduce spending in any discretionary areas to lessen existing cash-flow needs, as well as handled indirect cost during falling production.

Most of the respondents outlined that the current economic situation in Russia might cause additional risk factors that had not existed or did not have a strong influence on the companies in the pre-crisis period. As the economy declines, new emerging threats to sustainable development may include constraints on the availability of capital and credit, concern and liquidity issues, degrading purchasing power of population, high inflation, and volatile markets, which taken together result in significant uncertainty of doing business. Coles et al. [77] examined two measures of risk, which were stock return volatility and cash from volatility, and found that, through financial policy, increasing risk could generate uncertain performance. The idea was supported by Goel and Thakor [107], who provided a model that addressed the relationship between risk-taking, competition, and tournament incentives, Kini and Williams [108], who revealed the link between risk and internal tournament incentives, and Chen et al. [109], who applied the risk-performance link to competition. The survey demonstrates, that, in the future, the respondents see the greatest increase in demand in risk management, variance and breakeven analysis, and activity-based management. This means that the expectation of continuing economic decline directs the businesses to turn into contemporary MA techniques, as opposed to traditional cost accounting systems. This finding agrees with those from the studies of Scorte et al. [110] and Angelakis et al. [111] who both report an increasing trend for organizations to risk and place greater emphasis on currently developed techniques instead of traditional performance evaluation techniques. According to Coles et al. [77], in determining firm risk, managers face potential costs of reduced expected utility arising from exposure to risk through performance-contingent compensation. Kale et al. [112] suggested that in order to increase the probability of success, the firms set a higher internal promotion-based tournament prize. A convexity in executive compensation can offset the risk exposure and possibly increase the incentive to take risk in changing MA practices among the managers [113,114]. In a volatile environment, a less risk-averse manager inspired by higher competition and tournament incentives will take more risks and potentially earn more through increased option value, which leads to higher performance of a firm but threatens sustainability. In case of Russia, we see that this suggestion complies with a hypothesis of Coles et al. [77] that the usage of financial and accounting policies that increase firm risk will, in turn, distort sustainability, decrease investment in hard assets, and increase the industry gap. Peer groups as substantiated by Bizjak et al. [115], and Faulkender and Yang [116,117] may be used in setting compensation levels for the specialists responsible for management accounting.

In many prior studies, firm size has been employed as an important firm characteristic. Size effect, the relevance of firm size in determining the dependent variables, has been observed by Dang et al. [89], Baker and Hall [118], Coles et al. [119], and Frank and Goyal [120], among others. Vijh and Yang [121] found that the sign and significance of firm performance variables were sensitive to different firm size measures. Our study demonstrated that in Russia, the intention to increase the use of risk management and performance-oriented accounting tools did not diverge across the sectors or firm sizes. We found, however, that small and medium enterprises, in the main, implemented a narrower set of MA tools compared to large companies. Primarily, SMEs used simple MA instruments, such as pricing, and thus were not able to diversify them. Since most of the MA tools are generally rather resource intensive, in the times of economic decline, Russian SMEs have been decreasing using budgeting tools and instead stressing on personal control of resources and expenditures. Similar to our finding, Fiala and Hedija [122] did not detect a clear dependence of performance management and accounting practices on firm size, but Lotti et al. [123] expected that such a link might become valid in the long run, when the economic volatility decreased and markets tend to approach a steady state.

6. Conclusions

In a global context, the emerging volatility of the markets along with the evolution of the regulatory framework have changed the determinants of corporate performance. In this increasingly volatile business context, sustainability management has generated demands for the adaptations of conventional management accounting to serve the resilience-related goals. Prior to and in the times of economic decline, accounting policies of a company are essential for its sustainable performance. In a down economy, the importance of management accounting increases as its major goal is to generate the necessary information about external environment, relaying it to changing the internal one. The primary focus of this paper was to examine whether the change in the business environment, particularly, economic recession, affects the level and set of management accounting tools. Given the relative novelty of sustainability as one of the goals of management accounting in Russia, it was not surprising to find a high level of variety in MA practices among Russian companies. The survey demonstrated that they used a number of tools across a range of operational, managerial, and strategic functions. Although several MA instruments were in use across the sample of surveyed companies, the range of different methods within each company was usually limited. Both the importance and popularity of particular MA tools varied depending on the external economic factors.

The contribution of this study to the literature involves the understanding of the use of particular MA tools before and during the economic recession. Comparisons were made between management accounting practices used by the organizations differentiated by their size (micro, small, medium, and large), sector (service, industry, trade, agriculture, and tourism), and location (territories of Russia differentiated on the level of their economic performance). Out of 54 management accounting tools, the most popular ones were identified across ten categories (cost, price, budget, profitability, investment, performance measurement, performance management, rewards, performance reporting, and strategic techniques) and three pillars (operation, management, and strategy). The major finding is that both importance and usage of proactive strategy-oriented tools decreased during the crisis, while at the same time the level of importance and usage of less-sophisticated short-term instruments increased as the organization focused on achieving immediate and direct effects on sales, profits, and other performance parameters. The forecast of future application of management accounting tools in the situation of progressing economic decline revealed that organizations of all types and sectors planned to increase the use of such practices as risk management variance analysis, rolling forecasts, payback, breakeven analysis, and activity-based management in response to deteriorating economic conditions.

The survey approach used in this study imposes particular limitations, as well as emerges some directions for future research. Specifically, the contribution to the knowledge about MA–crisis–sustainability relations cannot be achieved through interviews alone. In the volatile environment, it is necessary to study the change within the firms in adopting a SR framework and integrating sustainability issues into short-term planning and operative decision making. The interviews allow the observation of a correlation between economic volatility and MA change but did not contribute to the understanding of what actually drives the change towards improved sustainability performance. The endogeneity problem exists as the study observed a correlation between the external environment and the change in use of MA tools in all three scenarios, but does not explain causality. The role of particular MA tools in facilitating organizational changes in response to the economic crisis has remained underexplored. Further research should, therefore, focus on possible mitigation of endogeneity by using a combination of methods, including lagged independent and control variables (suggested by Li [76]) and system generalized method of moments (transformed by Abdallah et al. [78]). This will allow assessing organizational transformations induced by management accounting and the relative effectiveness of certain accounting practices in responding to external economic fluctuations.

The impacts of ownership, size, and sector on the attitudes of a company to sustainability-oriented use of MA tools might be explored further. The survey format of the study has not allowed us to collect relevant commercially sensitive information on all possible firm size measures in the case of Russian organizations. We, therefore, utilized the open information on the number of employees as a proxy, but the researchers can use some alternative firm size measures such as total assets, total sales, market value of equity, enterprise value, total profits, or net assets. All those proxies can be mechanically correlated with the dependent variables of performance and sustainability, therefore, the empirical sensitivity should be considered.

Due to the fact that this study included the companies from five sectors only, there is an opportunity to extend the research to a wider pool of industries, specifically, to banking (to study the changes in application of MA tools in banks and financial organizations in turbulent financial markets), oil and gas (to see if export-oriented resource companies ever react ro the deterioration of the economic situation in the domestic market), and retail (to investigate the MA-related reactions of retailers on degrading purchasing power of population during an economic crisis). It is also worth studying the recession-induced effects of tournament incentives on performance, risks, and sustainable development, specifically, in banks and financial firms, for which Coles et al. [77] earlier reported a statistically significant positive effect of industry tournament incentives on the volatility of cash flows and stock returns. Within the sectors, the selection of incentives and setting of compensation levels for the managers should be studied based on the peer groups method in the light of relative peer effects, as suggested by Bizjak et al. [115,124] and Faulkender and Yang [116,117]. Understanding how peer groups are established for the purposes of relative performance evaluation is important to understanding the incentives for accounting managers and specialists for changing MA practices in volatile economic environment.

Since the data were collected in Russia, the results of the study may be generalized for the specific pre-crisis and crisis periods in this country only. The study should, therefore, be extended to other countries which either have recently experienced an economic recession (Greece, Portugal, Ireland) or currently have an economic situation similar to that in Russia (Kazakhstan, Ukraine, Argentina, Brazil). Such extension will allow cross-country comparisons. Replicating the study in other sectors apart from service, industry, and trade (finance and banking, retail, or information technologies) could allow extending the research and uncovering cross-sectoral variables which may further enhance the understanding of the role of management accounting in ensuring sustainable development in the times of economic decline.

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sustainability

Article

Factors Influencing Energy Consumption in the Context of Sustainable Development

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Abstract: Based on the global need to reduce the primary and final energy consumption, as part of the climate change mitigation strategy, the present study aims at determining the influence of different economic, social and environmental factors on the two types of consumption while emphasizing the importance of this topic for the research area. The novelty of the study resides in the factors considered in the panel analysis as well as in the combination of the analysis methods: the panel data analysis and the bibliometric analysis. The main results show that factors such as greenhouse gas emissions, gross domestic product, population and labour growth have a positive relationship with both primary and final energy consumption, which means an increase of energy consumption. Meanwhile, factors such as feminine population increase, healthcare expenditures or energy taxes have a negative relationship, which determine a reduction of energy consumption. The results should be of interest to the authorities in designing new energy reduction policies for contributing to sustainable development goals, as well as to the researchers.

Keywords: sustainable development; energy consumption; econometric model; bibliometric analysis; relationship

1. Introduction

The possibility of harnessing the free energy that surrounds us or that of reproducing it for providing light or heat has puzzled scientists for centuries. Either by burning some natural resources such as oil or coals or by experimenting ways of multiplying the natural lightening, people such as Thomas Edison [1], tried to satisfy their basic needs, those of heat and light. New inventions, such as Faraday's dynamometer in 1830 [2] allowed people to use electric power for building machines and finally, it represented the beginnings of the Industrial Revolution. This new era in the history of mankind proposed models for the development of society based on intense use of resources; it contributed to setting the world great powers, and along with development, there comes an increase in a country's energy consumption [3].

Yet, the Industrial Revolution also had side effects, on economic, social and environmental levels. Those countries which could afford to invest in developing the industrial sector are still economic world leaders, a fact that roots social disparities [4] and those which are currently developing are expected to increase their energy consumption [3,5] since there is an obvious relationship between energy consumption and economic growth [5]. This also caused severe environmental damage, understood mostly by climate changes [6]. Some experts use the term eco-crisis to describe the recently formed economic and ecologic relationship [7].

Since the 1970s [8] the attention was drawn to the major global growth drivers of eco-crisis, namely: Population, agriculture, industry, social inequality, natural resources, including energy resources, and pollution. Since then, several experts have turned their attention on the relationship between energy consumption and economic factors influenced by it [9] or on energy consumption and environmental factors [10,11].

Even more, it is worldwide acknowledged that energy consumption must be reduced in order to mitigate the climatic changes that constantly occur because of it. The United Nations, through their 2015 sustainable development strategy named the 2030 Agenda has developed a set of 17 sustainable development goals [12], number seven in this set of goals is refereeing directly to the energy sector: "Affordable and clean energy". This goal has two sides, one of them related to increasing the accessibility to electric power for the poor or isolated communities, and the second side, related to increasing the percentage of renewable energy sources in the total consumption of energy and even replacing conventional energy with renewable energy production.

Undoubtedly, the holistic management of the resources plays a key role in meeting sustainability goals, and the energy sector is an important part of this puzzle. The current situation of environmental degradation manifested by the overexploitation of energy resources and the intensification of climate change, known as the eco-crisis, occurred on the background of the Industrial Revolution.

Yet, we must ask ourselves, what are the critical influencers of the energy sector? Where should we focus in order to develop a sustainable energy sector? There are also other experts who contribute to solving these questions [13–17] by studying the relationship between energy consumption and gross domestic product. However, some of the results are inconclusive or mixed and they heavily depend on the indicators considered and the methodology chosen.

Therefore, the need for retesting some of the already analysed variables is obvious, as it is the inclusion of new indicators and indices of the social, economic and environmental system in previous models, which have not been tested yet [18].

In this case, this study aims to assess the energy determinants at European Members level (EU28) through a holistic approach of the system (including all the areas: Economic, social, environmental, etc.) in order to identify critical points (some not yet explored) which influence the sustainability of the energy sector.

The constructed models consider the literature in the field, as well as the testing of new determinants of the considered endogenous variables.

The data was gathered from several data bases: Eurostat [19], World Bank [20] and the Energy Information Administration—EIA [21]. The multitude and diversity of the indicators analysed, and the models considered are a necessary contribution to substantiate the proposals to improve the European Union energy and climate targets and policies. The region was chosen due to the availability of the data, as well as for the historic importance and the presence of both developed and developing economies.

A first objective of the research is to analyse whether the relationship between the energy consumption, emissions and the economic sector poses an interest for the researchers, through a bibliometric analysis of the articles available on the Web of Science database.

The second objective is to analyse the factors that should be prioritized in order to reduce energy consumption at EU28 level for mitigating climate change and reducing the risk of worsening social welfare.

The final objective is to highlight the implications of research on sustainable energy policies at a European level.

The present paper is structured into four main sections. The first section presents the main findings in the literature on this topic, which are relevant for the current discussion. The second section regards the chosen methodology and presents the construction of the present analysis and models. The third section presents the main findings of the research and it is structured in three main subsections, first presenting the results of the bibliometric analysis, second, presenting the results of the panel data models on the primary energy consumption and third, presenting the results of the panel data models on the final energy consumption. The fourth section discusses the obtained results by comparing them with other relevant studies and by providing a series of recommendations. The paper ends with a concluding section.

2. Literature Review

The causality between energy consumption and economic growth has been approached by several authors. For example, the study of Caraiani et al. [15] confirms the causality between primary energy consumption from different sources and gross domestic product for Bulgaria, Poland, Romania, Hungary and Turkey between 1980 and 2012/2013. Paul and Bhattacharya [22] studied the relationship between economic growth and energy consumption in India for the 1950–1996 period and they found that there is both a bidirectional causality and same direction causality between the two variables. Asafu-Adjaye [9] proves in his study on Indonesia, India, Thailand and the Philippines that the relationship between energy and income is not a neutral one, hence, energy consumption is influenced by the income variation. A similar observation is made by Aqeel and Butt [23] who prove that the economic growth of a country directly influences the growth of petroleum consumption in that country.

Other experts [10,24,25] demonstrate, with different approaches, that carbon emissions and energy consumption do not lead to economic growth, so their suggestion to the authorities is to pursue energy conservative policies and carbon reduction policies since they don't interfere with the economic development of a country. Their results are very important for supporting the global strategies of energy consumption reduction.

Another study [26] aims at determining the existing relations between the energy consumption from different energy sources and the economic growth in the case of Romania, Spain and the EU27 average, on short and long term. The authors [26] prove the existence of unidirectional relations from energy consumption towards gross domestic product (GDP), notably the causal influence of renewable energy consumption on economic growth in Romania and Spain. On the other hand, Aspergis and Payne [27,28] find that there is a bidirectional causality between economic growth and renewable energy consumption, based on their studies on different sets of countries. Further studies of Aspergis and Payne [29] on a panel of 80 countries showed that there is a positive impact on real GDP from both renewable and non-renewable energy consumption, since there is only a small difference in the elasticity estimates of the renewable and non-renewable energy consumption.

Çoban and Topcu [16] investigate the effects of economic growth, energy prices and financial development indices on energy consumption at the EU27 level. At the same time, comparing the 15 older EU states with the 12 newer ones, they note that an increase in energy consumption due to higher financial development in the EU15 countries, as the rest of the member states have a less developed financial system, especially with regard to stock exchanges, which limits its impact on energy consumption. However, a poorly developed financial system produces negative effects on investments in energy efficient technologies, these effects being suggested by energy intensity above the EU average of the EU12 countries [16].

More recent studies [14] confirm the differences between developed and developing economies, showing that the use of energy from renewable sources has a higher influence on economic growth of the countries with higher GDP than for those with lower GDP.

Other approaches [30] show the influence of emissions, GDP, financial development, capital stock and population on energy consumption. In addition, Stadelmann and Castro [31] propose unusual indicators to be analysed in the estimation of energy consumption in relation to public policies in 106 states during 1998–2009.

The causality between carbon dioxide emissions, energy consumption, gross domestic product, and foreign direct investments is investigated by Kim [32] who claims that there is no direct short-term causality between foreign direct investments and CO_2 emissions, based on a study on 57 developing countries in the 1980–2013 time frame. His results do not support the idea that foreign investments positively influence the CO_2 emissions. However, Nasir et al. [33] claim the contrary. By using a panel data analysis on data from 1982 to 2014 in five East-Asian economies, they [33] find that financial development, economic development and foreign direct investments have a statistically significant long-term relationship with environmental degradation represented by CO_2 emissions. In fact, financial development and foreign investments leads to an increase in environmental degradation.

By studying the relationship between energy consumption and economic growth in the countries known as BRICS (Brazil, Russia, India, China and South Africa), Baloch et al. [34] suggest that there might be a correlation between the abundance of natural energy resources and CO_2 emissions, based on a panel data study from 1990 to 2015. Their [34] results show that the abundance of resources mitigates the emissions in Russia, while in South Africa it increases them. Aydin [35] finds that in the same BRICS countries the increase of biomass energy consumption use would have positive results towards sustainable environment, economic growth and energy dependency reduction.

Salim et al. [36] uses a linear and non-linear econometric approach to see the effects of urbanization on pollutant emissions and energy intensity in developing economies of Asia. Their results show that population, prosperity, and non-renewable energy consumption are major influencers of pollutant emissions. A more important result is that for the countries which achieved a certain level of development, their emissions tend to decline.

While investigating the literature review on the methodology used for studies in this field, it was observed that the top-down methodological approaches on the evolution of environmental conditions and the energy sector take into account energy market components, but do not include technological development in the analysis, while bottom-up approaches use the model of overall balance to capture the determinants of change in the energy system and the natural environment, such as emissions, energy efficiency and technology, without considering the feedback from the economy [37]. These limits have led to the emergence of a mixed approach that suggests feedback, but due to the nature of the equilibrium models, it still fails to surprise those [37].

Considering the proposed policies suggested by different authors, we mention the Colombian case, where a low-carbon policy would preserve low emissions in electricity generation [37]. Other studies [38] use the non-causality in heterogeneous panel test to see if the exploitation of renewable energy sources in the EU-28 countries is an achievable solution for environmental pollution mitigation. Their results suggest that it is possible to reach the sustainable development goals until 2030 through renewable energy consumption and carbon emission mitigation, so they support the policies regarding renewable energy promotion. Some authors [39] support the idea that one policy could not work for each case, so a mixed policies approach should be considered based on the specificities of every country. Another study suggests a policy of rewarding the most efficient countries by granting them potential increases in emission and energy consumption while the least efficient countries must bring decreases to achieve full efficiency by applying the modelled reallocation [40].

According to Belke et al. [41], most of the current models for analysing energy relations and economic growth are based on the model of production functions such as Saidi and Hammami's [30] study, which, however, does not include the price of energy, as most studies in this area. Even so, the data panel is preferred over time series and cross-sectional analysis due to its higher accuracy by including binary variables that capture different time series and different cross-sectional units with the fixed or impact effects model [42]. On the other hand, the Wang et al. [43] study includes influence factors such as the following: Energy prices, urbanization and GDP on energy consumption through a panel data analysis on 186 countries between 1980–2015, and it finds that energy prices negatively affect the energy consumption in low-and medium-income countries. Also, the study finds that urbanization is a very important factor which affects energy consumption per capita. Also, Lv et al. [3] support the idea that urbanization influences carbon emissions from energy consumption, but due to the new ecological or green trends followed by the urban population, the urbanization has an alleviation effect on the emissions level.

In opposition to urbanization, there is another high energy consumption factor, namely agriculture. Harchaoui and Chatzimpiros [44] discuss the possibility of reducing the energy consumption in agriculture. Their results show that the current agricultural model is structurally energy deficient. Basically, its functional energy requirements are almost equal with the final production. The energy potential from manure and crop residues (as biomass) could only equal the external energy needs of agriculture [44]. For agriculture to become an energy source it is supposed to stop feeding from cropland and to reach the maximum amount possible from the agricultural residues [44]. Tian et al. [45] propose a more thoughtful choice of production ways to improve the sustainability of agriculture, by reducing the energy consumption. Their observations prove that the amount of energy consumed for growing the agricultural product is very high and unadjusted to the geographical conditions; however, it could be easily reduced by adjusting to the area of growing [45].

Other authors [46] go further to propose renewable energy sources along with a pros and cons evaluation of the source. The main reason against the alternative energy source (geothermal energy) is the high investment needed to turn it into a viable system, which makes it an option only for developed countries. Whereas, in countries like Turkey, where there is an abundance of geothermal sources, the rapidly growing population and economic growth do not allow for a stagnation in the use of pollutant energy sources (such as coals) and the investment in harnessing the renewable energy source [47]. After Temiz Dinç and Akdoğan [48] demonstrate a bidirectional causal relationship between renewable energy and economic growth based on 1980–2016 data, they claim that increasing renewable energy production and decreasing energy consumption are a must for ensuring Turkey's sustainable development. Some authors [49] come with solutions appropriate for reducing the final energy consumption, based on a multi criteria analysis on the case of Italy, which proves the efficiency of using solar thermal panels combined with the heat pumps instead of the current system used for providing hot water and heat.

Mostly based on panel data analysis, on longer or shorter periods, most of the studies demonstrate the negative effects of energy consumption over the environment, through the polluting effect it has, but also the fact that it does not affect the economic growth of a country in a significant way. In this case, most of the recommendations of the experts incline to designing new policies, which should integrate investments in renewable energy production and replacing non-renewable sources, mostly used in the current situation.

3. Materials and Methods

This study uses both bibliometric analysis and panel data techniques. The first method represents a quantitative analysis of the literature review in the field in order to emphasize the importance trend of a topic, as well as its main areas of interest. The bibliometric analysis is conducted on the 671 articles found on the Web of Science database, in the 1975–May 2019 time frame, by using terms such as "energy", "emission*" and "economy" in the query and refining the results after the "relationship" filter word, in order to keep only the results which have a model included. After finding these articles on the Web of Science database, quantitative analysis was performed by investigating the trend of the scientific production in the field, the most prolific authors, the areas of interest, as well as the affiliated countries of the publications found on Web of Science. The method is useful in overviewing the previous results on the researched area, and it is constantly used in other studies [50,51]. Also, by using the Vosviewer software, the concepts mostly used in these articles and the relationships between them will be exposed [52]. This software creates word networks by analysing the title, the abstract and the keywords of research data from Web of Science. The limit of this technique is given by the fact that the information provided by the title, the abstract and the keywords of research data has a marketing purpose and, sometimes, it might reach subjects which are not thoroughly debated in the full corpus of the scientific publications. Nonetheless, the word networks give an overview of the areas of interests in the field.

Further, panel data is the econometric technique chosen to observe energy consumption determinants, as it is more comprehensive than time series or cross-sectional analysis [42]. In comparison with other studies in the field [17,30,53–56], this piece of research offers a more comprehensive analysis because of the numerous variables considered in the energy consumption influence analysis.

The estimation of the panels was conducted by testing the three methods explained by Wooldridge [57], namely: The common or non-effect constant method, implying assigning a common constant to all countries considered in the panel, not making the difference between states and periods; the fixed effect method, which allows the assignment of a fixed constant for each state/period, that is, the constant varies cross-sectional; and the random effect method, which allows the treatment of constants, which are not fixed for each state/period, as random parameters, which involve the inclusion of a new error due to differences in the fixed effect in the error term.

The multiple regression models include data on the categories of data presented in Tables 1–3.

Also, in the analysis was considered the square of GDP (GDP-2) in order to test the potential existence of a hyperbola shape.

Table 1. Eurostat variables used in the models [19].

Abbreviation	Explanation of the Variable	Measure Unit
PEC	Primary energy consumption	Thousand tons of oil equivalent
FEC	Final energy	Thousand tons of oil equivalent consumption
FFE *	Fossil fuels weight in total European Union (EU) internal gross energy consumption	%
RE *	The renewable energy weight in total EU internal gross energy consumption	%
NE *	Nuclear energy weight in total EU internal gross energy consumption	%
GHG	Greenhouse gas emissions	Thousand tons of CO_2 equivalent
ENVT	Share of environmental taxes in gross domestic product (GDP)	%

* Part of the energy mix. Source: Our own abstracting of the considered factors.

Table 2. World Bank variables used in the models [20].

Abbreviation	Explanation of the Variable	Measure Unit
REL	Renewable electricity weight in total electricity production	%
NEL	Nuclear electricity weight in total electricity production	%
GDP	Gross domestic product	US$ 2005 constant prices
IU	Internet users per 100 people	number
K	Capital stock	US$ millions of 2010 constant prices
WF	Workforce	Thousand persons
PD	population density	persons/km^2
POP	Population	Thousand persons
K-GDP	Namely gross fixed capital formation as a share of GDP	%
EIMP	Net energy imports as a share of the total energy used by a country	%
C-GDP	Financial development assessed by the share of credits granted to the private sector in GDP	%
SE-GDP	Trade openness valued through stock exchanges as a share of GDP	%
EB-GDP	The external balance of goods services as a share of GDP	%
RD-GDP	Share of research and development expenditure in GDP	%
M-GDP	Share of military expenditure in GDP	%
AA	Agricultural area as a share of the total area of a country	%
NR-GDP	Renting natural resources as a share of GDP	%
UPOP	The share of urban population in the total population	%
FPOP	Proportion of the female population in the total population	%
FM	Female legislators, officials and managers in leading positions	%
WP	Proportion of women's mandates in national parliaments	%
TEDU	The share of labour that followed tertiary education in the total labour force	%
H-GDP	Share of health expenditure in GDP	%

Source: Our own abstracting of the considered factors.

Table 3. Energy Information Administration (EIA) variables used in the models [21].

Abbreviation	Explanation of the Variable	Measure Unit
EP	Oil price	Brent oil price for Europe-$/barrel, transformed by applying the 2010 consumer price index

Source: Our own abstracting of the considered factors.

All these variables were chosen by investigating several scientific studies [16,17,30,53,58–63].

Our first hypothesis is that GDP, GHG (greenhouse gas emissions), the energy mix based on nuclear energy and fossil fuels, capital accumulation, financial development, trade opening, military development, internet access, agricultural area, population density, labour force, and the degree of urbanization has positive relationships with energy consumption, so it causes negative effects on the holistic system, which considers all three pillars of sustainable development: Economic, social and environmental.

At the same time, the use of renewable energy, the price of oil, net energy imports, research and development funding, environmental taxes, exhaustion of natural resources, female decision makers, health system financing and high level of education might have negative relationships with energy consumption, thus generating positive effects on the holistic system by reducing the use of energy. The more educated people, whom should be more aware of the current climate change and energy challenges and the higher access to internet might contribute to reducing energy consumption. In addition, the increased financing in the health system could contribute at energy savings and energy efficiency improvements.

For the study of the influencing factors of energy consumption, many models described by Equations (1) and (2) were tested and obtained.

$$PEC_{it} = \alpha_{it} + \sum \beta_{it} \times Economic\_Var_{it} + \sum \gamma_{it} \times Energy\_Var_{it} + \sum \lambda_{\mathrm{it}} \times \mathrm{Socio-Eco\_Var}_{it} + \varepsilon_{1it} \quad (1)$$

$$FEC_{it} = \phi_{it} + \sum \eta_{it} \times Economic\_Var_{it} + \sum \kappa_{it} \times Energy\_Var_{it} + \sum \varphi_{\mathrm{it}} \times \mathrm{Socio-Eco\_Var}_{it} + \varepsilon_{2it} \quad (2)$$

$\sum Economic\_Var_{it}$—Variables related to GDP, capital stock, internet users, gross fixed capital formation as a share of GDP, financial development, the external balance of goods and services, military expenditure, research and development expenditure in GDP. Each variable from this category tested in the panel model is attributed a different coefficient β_{it} or η_{it}, which offers information on the effect of the relationship with the endogenous variable and its impact. This means that the size and the sign of the impact of each variable in this category is different on primary energy consumption (PEC) and final energy consumption (FEC).

$\sum Energy\_Var_{it}$—Variables related to different types of energy consumption, energy mix, oil price and the share of net energy imports. To each variables from this category tested in the panel model, it is attributed a different coefficient- γ_{it} or κ_{it}, which offers information on the effect of the relationship with the endogenous variable and its impact. This means that the size and the sign of the impact of each variable in this category is different on PEC and FEC.

$\sum \mathrm{Socio-Eco\_Var}_{it}$—Variables related to population, female population, degree of urbanization, female legislators, officials and managers, the proportion of women's mandates in national parliaments, the workforce, the share of the labour force that followed tertiary education in the total workforce, health expenditure in GDP, greenhouse gas emissions (GHG) emissions, share of agricultural area in total area, environmental taxes as a share of GDP and rental of natural resources as a share of GDP. To each variables from this category tested in the panel model, it is attributed a different coefficient; λ_{it} or φ_{it}, which offers information on the effect of the relationship with the endogenous variable and its impact. This means that the size and the sign of the impact of each variable in this category is different on PEC and FEC.

$\varepsilon_{\mathrm{it}}$—Represents the error of each model [64];

i—Represents the geographic indication;

t—Represents the time considered in the analysis.

The energy mix has been tested by the energy consumption of fossil fuels (XFOS), renewable (XER) and nuclear energy (XEN) in total gross domestic energy consumption, according to several authors [54,59,65].

In addition, the independent variables were tested on both total and divided to the population and the results indicate insignificant differences. So, this research presents only the results which considered the total independent variables.

All the indicators used in the models present the state and the evolution of the society on a certain time frame. These have been introduced in the econometric models after fulfilling the hypotheses necessary for regressions validity. So, the data was tested for stationarity, the existence of a normal distribution, and multicollinearity between the variables used in the same model.

Data stationarity was tested for the variables of all models analysed by indicating the existence of the unit root at the panel and the individual series, i.e., the presence of autocorrelation between past data of the same variable [64], which should not appear in order to apply the regression model. According to the applied tests, most of the variables were not stationary at the first level, the stationarity being identified at their first difference, generally by considering a constant or a lack of trend and constant after the graph of the time series [18]. Also, natural logarithm was applied to the energy consumption, GHG, GDP accumulation of capital (K), population and workforce indicators for estimating the elasticity of coefficients of variables in regressions. Then the difference was applied in the case of non-static data [57], which leads to normalization of time series. This was the case of all variables considered in the models.

Further, the variables were considered for a model only if the collinearity coefficient was less than 0.5 and the causality between them was found present. The correlation matrix contributes to establishing regression models as it highlights the multicollinearity that does not have to be present between the regression variables [18].

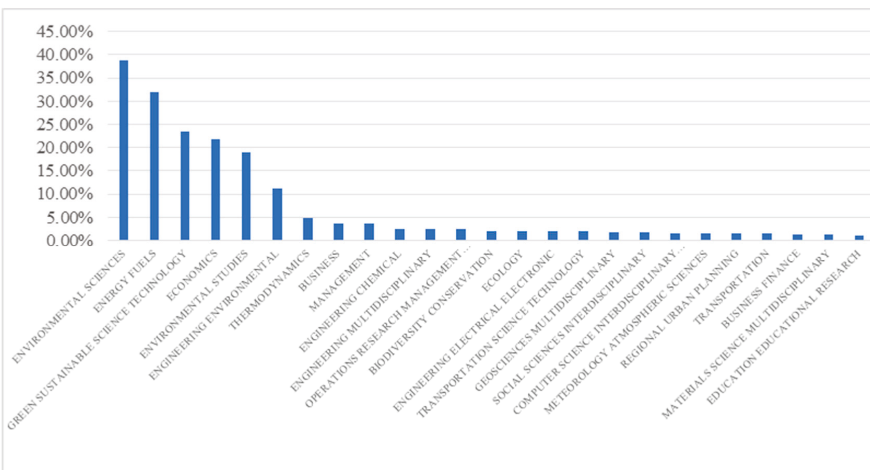
Moreover, the Granger test provided the existence of the causality between two variables, two by two, but there are a multitude of determinants of the analysed endogenous variables that act together within the holistic system. Therefore, those variables that appear to have no influence on the dependent variable may in fact cause changes in the endogenous variables. This can be highlighted by presenting the results of multiple regression analysis, which also highlights the sign of the changes made. So, the results of the causality tests were also considered in the construction of the models at the EU28 level during 1995–2014 [18]. Thus, it was found that there is a causal relationship of GHG and economic growth on energy consumption at EU28 level in the short and medium term, as demonstrated in previous studies by Kasman and Duman [17] for the EU12 and Saidi and Hammami [30] for 58 countries, of which EU15 can be observed. In addition, the economic and social determinants common to all two types of energy consumption analysed as endogenous variables are as follows: Capital accumulation, environmental taxes, oil prices, population, representatives in female leadership positions, labour force, and number of Internet users. In addition, percentage changes in both primary and final energy consumption are caused by past financial development, as is also the case of Saidi and Hammami [30] article, however, it does not capture the influence of capital accumulation. At the same time, trade openness, along with previous levels of natural resource depletion and agricultural surface, causes changes in primary energy consumption, like the outcome of Kasman and Duman [17], but no such evidence was found for the final energy consumption. Another interesting result is the causal influence of the urbanization change on the final energy consumption, which has not been econometrically demonstrated yet at EU28 level. Another important explanatory variable, RD-GDP, causes changes in the final energy consumption, a fact that is politically relevant by highlighting the importance of research in developing the technologies needed for energy sustainability. Finally, the past percentages of tertiary education workforce are generating changes in final and primary energy consumption, which highlights the importance of educating and informing employees about sustainability requirements and new green energy policies.

4. Results

4.1. Results of the Bibliometric Analysis

The bibliometric analysis is generated on 671 articles available on the Web of Science database, which resulted after using the terms "energy", "emission*" and "economy" in the query and refining the results after the "relationship" filter word in the 1975–May 2019 time frame. This search allowed to keep only the results with a model included. One may see that there is an increased interest from research for this topic, as several authors try to expose possible models for determining the relationships between the three areas considering different influencing factors.

Considering the Web of Science categories of research, as presented in Figure 1, 38.75% of the articles are related to the environmental sciences area of interest, followed by energy fuels (31.89%), green sustainable science technology (23.55%), economics (21.76%) and environmental studies (18.93%). The other areas of interest have a lower percentage, 19 of the areas of interest have less than 5% of the articles found under the mentioned conditions. Following the previous mentioned facts, one may understand that there are several research areas interested in determining the relationship between the three components (energy consumption, emissions and economy), and they may be grouped either under the environmental studies/ecology umbrella, either under the socio-economic studies umbrella.

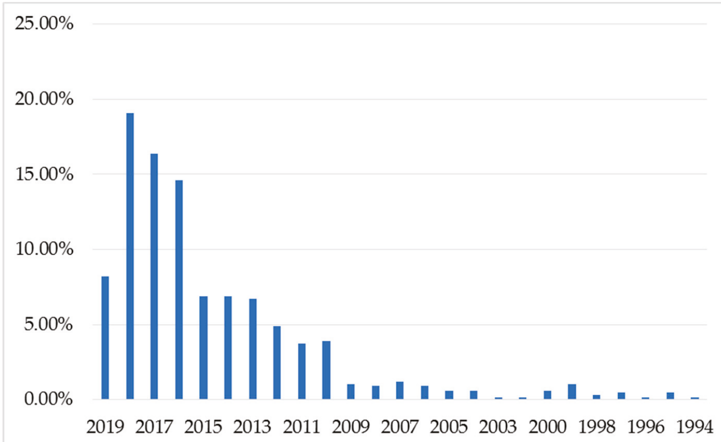


Source: Our own quantitative data processing of the 671 article abstracts downloaded from Web of Science.

Figure 1. Percentage of articles in the Web of Science research categories.

The interest in this topic has increased in recent years, as one may see in Figure 2. The first article appeared in 1994, and until 2010 the number of articles per year remained under 8, only 8.64% being published in this time period. In 2010 the number of articles reached 26, and it sky-rocketed in 2017 (110 papers) and 2018 (128 articles). In 2019, until May, there were already 55 articles published on this area of interest. The significant increase of interest in the area may come from the higher pressure posed by the current consumption pattern and the need to find better ways of living, as well as from the different options of renewable energy presented by the researchers.

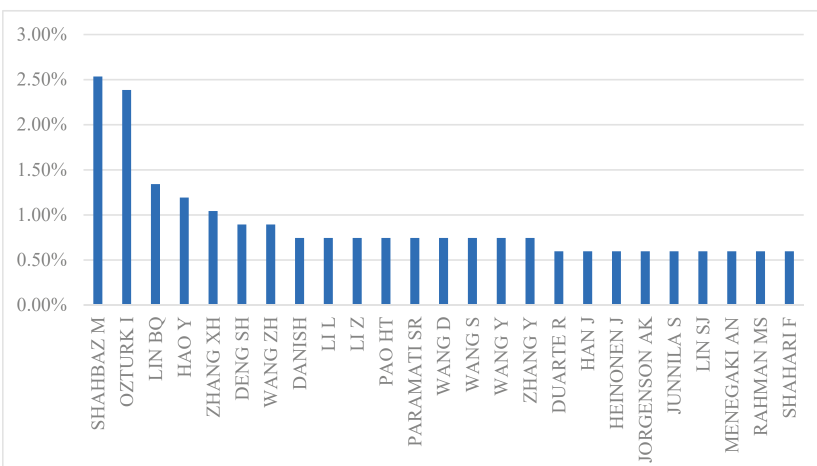
From the total number of papers, almost 74.5% (500) are journal articles, 17.75% (119) are conference proceeding papers, 9.25% (62) are reviews, while less than 2% are other types of papers, such as book chapters.



Source: Our own quantitative data processing of the 671 article abstracts downloaded from the Web of Science.

Figure 2. Publishing years.

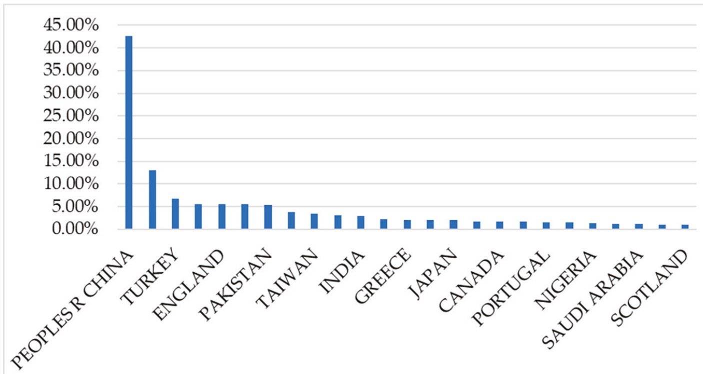
The most prolific ten authors on this field, as shown by the analysis, have more than five articles written in this area of interest. In Figure 3, it can be seen that Shahbaz M has is on the top with, 17 articles (2.53%) written on the topic, followed by Ozturk I with 16 (2.39%) and Lin Bq with nine (1.34%) articles. It must be mentioned that all of the authors who published in this area of interest have at least four (0.60%) articles written on the topic, which can be understood as an offering field and a dynamic one, which needs to be constantly analysed.



Source: Our own quantitative data processing of the 671 article abstracts downloaded from the Web of Science.

Figure 3. Publishing authors.

The source countries for the articles written in this field come from The People's Republic of China, where around 42.62% (286) of the articles have this source country. The following source country is the USA, with a dramatic difference of approximately 29%, as 12.97% (87) of the articles were written by authors of this country. The top three is completed by Turkey with 6.86% (46) of the articles being written here. Other countries, where the authors show an increased interest in this area of research, are Australia, England, Malaysia, Pakistan, Spain, Taiwan, France and India, as it can be seen in Figure 4. Even if most articles come from China, the first two authors in this area have different origins. Yet, the highest proportion of authors comes from this country.

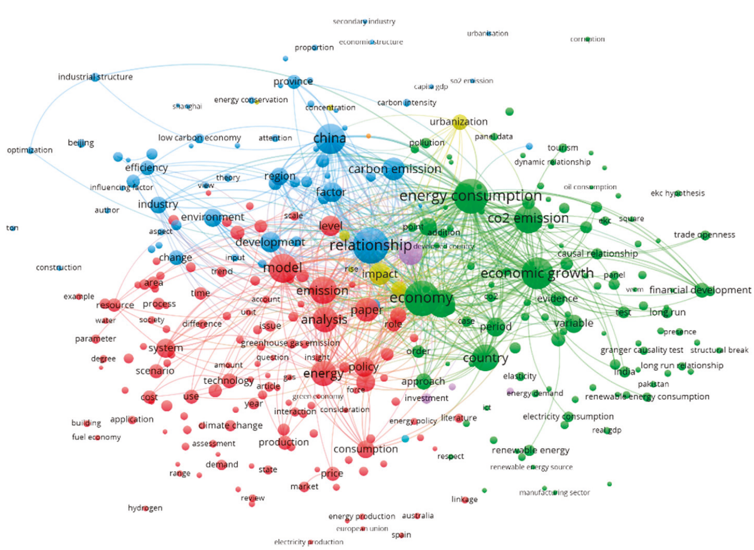


Source: Our own quantitative data processing of the 671 article abstracts downloaded from the Web of Science.

Figure 4. Publishing countries.

More than 99% of the research articles analysed are published in English, as the common language of researchers around the world. Only 0.3% of the studies are published in Chinese, 0.3% in German, 0.15% in Spanish and 0.15% in Turkish.

By using the Vosviewer software, the most used concepts in the analysed articles will be exposed on a network map presented in Figure 5. From the total number of words used in the 671 articles, 12,959, on the map are included only those terms which appear at least 15 times in the analysed corpus.



Source: Our own data processing of the 671 article abstracts downloaded from the Web of Science with Vosviewer.

Figure 5. Most used concepts-network map.

On the map, the most used concepts in the analysed paper abstracts are gathered in three main groups, differentiated by colours. In red, there are several focal points: Emission, energy, policy, consumption, role, level, scenario and production (terms such as model, paper and analysis may come from the article description and are not relevant for the current analysis). One may say that the macro elements of the "energy system" are included in the red cluster, from the resources and production, to the consumption and the emissions. In blue, there are two types of terms, one related to possible producers of emissions, such as China or Beijing—with direct names and county, regions, city—ass general geographical structures or industry, industrial structure—as economic sources of emissions. The second type is related to possible solutions of improvement, such as the following terms: Low carbon economy, change, development, efficiency, emission reduction or energy saving. In green, the group is formed mostly by the economic related concepts, such as: Economy, economic growth, energy consumption, growth, financial development or country.

It is important to mention that the term relationship is in the middle of the map and it connects all the focal point of the current research (energy, emission and economy), but also other important aspects that prove the right selection of papers for this analysis, such as: Model, variable, analysis or granger causality test.

4.2. Results of the Panel Data Models

In the proposed models, the determinants of energy consumption are estimated by using EU28-tested data panels for the period 1995–2014. The 17 developed models have been tested for the relevance of fixed effects, as well as to see if the random model is a better estimate than the fixed model. In this respect, the fixed effects test, as well as the Hausman test, was applied to both cross-sectional and period correlations, taking into account the null assumptions of each model presented in the methodology. The direction and magnitude of impacts of socio-economic and environmental determinants of primary and final energy consumption are presented and discussed in the following two sections [18].

4.2.1. Determinants of the Primary Energy Consumption

In order to identify the variables that may have an impact on the primary energy consumption, several variables were used, by investigating multiple international databases, which were presented in the materials and methods section. Along these, there could be also other indicators with various influences both as a sign and as a magnitude depending on the combinations considered in the multiple regression models. The results obtained from Equation (1) are highlighted in Table 4.

The regression results of estimating the percentage change in primary energy consumption as an endogenous variable in Table 4 indicates that there is a primary energy cost that EU countries have to assume. All independent variables, which registered a negative sign of the coefficients in Table 4, have a negative relationship with the endogenous variable, which can be translated as a positive effect on reducing the energy consumption and mitigating climate change. Contrary, the positive signs indicate a positive relationship with the endogenous variable, which can be translated as a negative effect on reducing the energy consumption, as the effect is one of growth.

Model 8 and model 10 suggest a linear negative impact of the change of economic growth (GDP) on the dependent variable, in the sense that the 1% augmentation of GDP determined an increase of PEC by 0.38% and 0.32% during 1995–2014. Although the relationship is positive, the effect is considered negative because one of the objectives of sustainability is saving energy through conservation and energy efficiency.

Table 4. Results of the multiple regressions regarding the percentage modification of primary energy consumption.

	Dependent Variable: Percentage Change in Primary Energy Consumption (PEC)									
Variables	**Model1**	**Model2**	**Model3**	**Model4**	**Model5**	**Model6**	**Model7**	**Model8**	**Model9**	**Model10**
Constant	0.0229 (p = 0.1868)	−0.0028	−0.0005	−0.0061 **	−0.0058 *	−0.0043 (p = 0.178)	0.0021	−0.0160 ***	−0.0079 ***	−0.0077 ***
GDP	0.0521							0.3868 ***		0.3239 ***
GDP-2	0.0817		1.4464 **		2.1064 ***	1.29 *	0.8832 *	1.0191 (p = 0.176)	0.0944	
GHG	0.8139 ***						0.7537 ***			
RE	0.0025 *		−0.0098 ***		−0.0127 ***					−0.0098 ***
FFE		0.0083 ***				0.0014		0.0026 **		
NE				0.0066 ***			0.0080 ***		0.0053 ***	
EP	0.0077 *		0.0116 **		0.0813 **	0.0096 *	0.0141			0.0133 **
REL				−0.0026 ***		−0.0026 ***			−0.0023 ***	
NEL	0.004 ***		0.0026 ***		0.0025 ***					
K		0.0908 ***		0.1063 ***					0.1336 ***	
K-GDP			0.0032 ***			0.0042 ***				
EIMP				0.0007 (p = 0.161)	0.0001	−0.0012 **		−0.0010 *		
C-GDP	0.0002 ***	0.0002 **					0.0002 ***		0.0001 *	0.0002 **
SE-GDP										0.00009
EB-GDP					−0.0024 **					−0.0017 *
M-GDP						0.0147	0.0123 (p = 0.166)			−0.0003
RD-GDP		0.013						0.0279 (p = 0.177)		0.0586 ***
AA								−0.002	−0.0006	0.0025 *

Table 4. *Cont.*

	Dependent Variable: Percentage Change in Primary Energy Consumption (PEC)									
Variables	**Model1**	**Model2**	**Model3**	**Model4**	**Model5**	**Model6**	**Model7**	**Model8**	**Model9**	**Model10**
NR-GDP		0.0074 *	0.0054 ($p = 0.190$)	0.0070 *				0.0075 ($p = 0.100$)		
ENVT							0.0053	−0.0071	−0.0102	
POP				0.5513 ***			0.5109 ***			
PD			0.0019 **		0.0016 *				0.0013 ($p = 0.112$)	
UPOP						0.0117 *		0.0157 **		
FPOP						−0.1020 **	0.0379	−0.1500 ***		
FM					0.0013 *		0.0008 *			
WP					0.0003				0.0010 ($p = 0.179$)	
WF		0.2841 ***			0.3126 ***					0.1934 *
TEDU						0.0005	0.0004		0.001	
H-GDP		−0.0113 **		−0.0120 **			−0.0066 *			
IU			0.0002	0.0008 *		0.0003				
Cross-sectional fixed effects	0.397	0.6305	0.5879	0.9574	0.3832	0.6306	0.5593	1.0405	0.3554	0.8196
Time fixed effects	1.8974 **	8.7024 ***	10.4632***	8.1307 ***	10.6465 ***	9.2658 ***	3.9447 ***	5.5346 ***	10.4968 ***	7.0418 ***
Hausman test: Random cross-sectional effects	no	no	no	no	no	no	no	no	no	no
Hausman test: Random time effects	23.3549 ***	10.0986 ($p = 0.183$)	20.6306 ***	23.6940 ***	39.8784 ***	59.9496 ***	58.0518 ***	36.8054 ***	43.1908 **	16.4772 *
R-squared	64.26%	20.43%	42.61%	46.43%	45.54%	40.01%	78.78%	34.82%	46.39%	49.31%
F-statistic	32.80 ***	14.41 ***	13.73 ***	13.53 ***	12.65 ***	10.48 ***	46.22 ***	8.32 ***	11.58 ***	11.60 ***
Durbin–Watson	3.02	2.14	2.22	2.06	2.41	2.28	2.75	2.16	2.33	2.31

Note: Statistical significance, p-value, * 10%, ** 5% or *** 1%. Source: [18].

In contrast to the study of Çoban and Topcu [16], which identifies mixed relations between economic growth and energy use at EU27 level during 1990–2011, the results of the current economic growth impact on primary energy consumption in the EU28 during 1995–2014 suggest only linear relationships of intensification of the endogenous variable. However, if we consider the separate findings of Çoban and Topcu [16] in the case of the old member countries and the case of the new ones, then the results are similar to this study. Nevertheless, the magnitude of the change induced by economic growth cannot be compared with the study by Çoban as Topcu [16], as they reported the variables to the number of inhabitants achieving increases in energy use per inhabitant of 0.03–0.04% over a different period. In addition, the results are similar to the study by Saidi and Hammami [30], which notes the increase in energy consumption caused by GDP per capita. Thus, correlations with specialized researches in the case of the economic growth of the EU28 on primary energy consumption suggest that studying aggregates in a variable generates a clear, positive relationship with a high negative impact, increasing consumption as a state develops on the economic level.

The relationship between GDP and PEC suggest that, for the time being, the EU28 still needs to stimulate the decoupling of economic development from energy consumption. As other studies [10,24–26] demonstrate, this decoupling would not affect the further development of the member states. In addition, this lack of decoupling, which will intensify energy consumption, can be attributed to the new EU states (EU13), which still do not have the same level of economic development as the EU15 and therefore energy consumption will not diminish if economic growth will improve in the new member states, i.e., the EU13, including Romania, without strong active measures to change consumer patterns and achieve energy saving. However, in order to substantiate this statement, as Çoban and Topcu [16] realize, a future study could retest the models presented in Table 4 at EU15 and EU13 levels.

Moreover, the increase of energy consumption stimulates the growth of greenhouse gas emissions, which further contribute to climate change [66]. In this context, the aim of the EU decision makers could be to stimulate and evaluate the social welfare though other indicator than GDP. Further, one focus of the developed countries could be the implementation of green technologies, which are more energy efficient and register energy savings. In terms of developing countries, these could aim to increase their GDP by also adopting environmental and social-friendly practices, as these are viable in the context of the fast climate change.

At the same time, the change in GHG emissions, which growth in the analysed countries by 1%, has led to an increase of the primary energy consumption (PEC) by 0.75–0.80% in the period 1995–2014. This fact is given by the positive relationship between the influences of GHG emissions on primary energy consumption, which is presented in Table 4 through the + sign of the coefficients. This negative effect of stimulating energy consumption due to increased pollution, which supports the research hypothesis, is similar to the findings of Saidi and Hammami [30], who introduce part of the EU countries into their analysed group. Similarly, Wang et al. [11] show GHG emissions as a determinant of increasing energy consumption internationally. While the relationship between GHG emissions and energy consumption seems to be a bidirectional one, as shown in our analysis and that of [66], the decision makers should focus on reducing energy consumption through various measures, such as financial incentives or tax reductions on sustainable practices, promotion of the importance of both energy savings for the consumer sector and energy efficiency in all sectors of economy, changing the behaviour of consumers by applying punitive measures for those who do not comply with the regulations in the field, and so on.

Similarly, the energy mix from fossil fuels (FFE) and nuclear energy (NE) generated a 1% increase in the change in primary energy consumption by 0.008% and 0.006%. This result, in the case of the share of fossil fuel consumption, may be caused by their still intensive use. In the case of the share of renewable energy consumption (RE) it is observed that the effect is contrary to FFE and NE, i.e., positive, of diminishing the dependent variable, PEC, by 0.009–0.012%. The impact meaning and magnitude are similar in the case of the change in green electricity production (REL) and that from nuclear sources (NEL). Thus, the benefit of reducing the primary energy consumption generated by the use of renewable energies is captured. This means that the decision makers should focus on developing public policies which aim at stimulating the production and use of renewable energy, bearing in mind as well the requirement of energy savings.

Contrary to the research hypothesis, the positive sign the oil price change (EP) in relation to the change in primary energy consumption shows that the 1% increase of oil price produced a growth of 0.007–0.081% of PEC during 1995–2014. Subsidizing the fossil fuel industry can explain this effect as well as the price of these non-renewable resources that do not include the negative externalities of the environment and human health. This is contrary to the findings of Çoban and Topcu [16], who identify a negative relationship in the EU27, between 1990 and 2011, a positive effect of lowering the use of energy per capita based on rising oil prices. Indeed, the differences in the analysis are related to the methodological approach, the data used, the time period considered and the target group. Thus, in the future, there is a need for reiterating this relationship for the EU28 and, again, its separate analysis for the EU15 and the EU13, with a view to homogenizing the groups.

The effect of changing the share of net energy imports as a share of the total energy used by a country (EIMP) on the dependent variable seems mixed, although the statistical significance only appears for the positive effect generated by the models 6 and 8. The positive effect of decreasing the consumption change of primary energy by increasing the share of net imports in energy consumption may be due to the promotion of the need for energy independence as well as the additional economic efforts of a country to source energy from imports, especially when the country owns the energy resources needed for energy security.

In order to deepen the impacts of the economic system indicators, other variables were tested. Thus, the changes in capital stock (K) and the change in gross capital formation as a share of GDP (K-GDP) lead to a negative effect on the change in primary energy consumption (PEC), in the sense that the increase of these indicators by 1%, it generates increases of PEC with 0.09–0.13% and 0.003–0.004%. This result is similar to the findings of Saidi and Hammami [30], who identify an increase in the use of energy per capita at the level of some 15 European countries due to capital stocks, but the relationship of this study is insignificant. Thus, the results in Table 4 suppress the statistical significance required for their validation. A lower negative effect also occurs in cases of change in financial development (C-GDP) and change in commercial opening (SE-GDP). Again, the impact of financial development on the rise in primary energy consumption is similar to that of Saidi and Hammami [30]. Also, the impacts of these two variables illustrated by the results are similar to the findings of Azam et al. [53]. Another indicator that captures commercial opening, but which has a positive effect on diminishing the change in primary energy consumption is the change in the external balance of goods and services as a share of GDP (EB-GDP), but its impact is very low, of −0.002%.

As with the impact on the change in the share of renewable energies in consumption, the change in the share of military expenditures in GDP (M-GDP) is not statistically significant on the change of the primary energy consumption, their correlation being inconclusive due to the mixed results recorded. Therefore, the research hypothesis that M-GDP growth would generate the augmentation of the primary energy consumption is not confirmed, producing a negative effect on the holistic system.

At the same time, contrary to the research hypothesis that R & D expenditure share (RD-GDP) in GDP generates a positive effect on the change in primary energy consumption in order to stimulate energy saving, the effect of this relationship is negative. A 1% increase in RD-GDP stimulated the endogenous variable enhancement by 0.058%. This surprising result indicates the failure of EU energy saving by 2014 and the possibility of a concave relationship between RD-GDP and PEC, as in the case of Kuznets. In addition, the same effect is observed with the change in the number of internet users (IU), whose 1% improvement causes a very small increase in the change in primary energy consumption by 0.0008%. However, the development of internet access implies the development of residential communications, indicating a better living and, implicitly, increasing energy consumption based on the use of electrical equipment and devices, confirming the results of Wang et al. [43].

The indicators considered for environmental assessment are either statistically insignificant, the case of changes in environmental taxes (ENVT), or they have opposite effects, the cases of changes in the weight of the agricultural area (AA) and the depletion of natural resources (NR-GDP). Although the research hypothesis implied a positive effect of ENVT on the change in primary energy consumption, the mixed and inconclusive results do not allow validation, nor its rejection. Instead, the negative impact of NR-GDP on PEC confirms the research hypothesis that energy consumption is growing as natural resources grow in exploitation, while the positive effect of AA on the endogenous variable rejects the hypothesis of research. Thus, as the change in the share of the agricultural area increases, the change in primary energy consumption decreases by 0.002%. This is surprising because the intensification of agricultural activities generates the increase in the use of energy. However, the development of green agricultural technologies can explain the situation identified at EU28 level.

Most social variables confirm the hypothesis of research. The most important social determinant, with a negative effect on the socio-ecological complex is the population. With a 1% increase in its change (POP), the primary energy consumption increased by 0.5%. This result is similar to that identified by Saidi & Hammami [30] generally applied for the estimation of energy use and shows that the population has a much more significant impact in the countries of Latin America than Europe. The same negative effect, but at a lower level, is also found for population density. In this respect, an increase of the population density (PD) by 1% determined an increase of the dependent variable by 0.001%. Also, the change in the degree of urbanization (UPOP) influenced only by 0.01% the primary energy consumption. This positive relationship, which sees a negative effect on the holistic system, is also indicated by Azam et al. [53] and Wang et al. [11], but for another geographic area, another period, and using another methodological approach, which of course has generated other magnitudes in the impact of urbanization on the increase in energy consumption. Obviously, agglomerations of the population intensify energy consumption, so the negative effect in this case proves the research hypothesis. Another significant negative impact is due to the change in the workforce (WF), whose 1% increase caused the increase in primary energy consumption by around 0.19% and 0.31%, depending on the factors of influence considered in the analysis.

Surprisingly, the increase in primary energy consumption is due to the rise of female decision makers (FM) as well as due to the increase in the share of educated workforce at least at tertiary level (TEDU). However, TEDU is statistically insignificant. Thus, it seems that the negative effects of these two indicators on the state of the holistic system must be carefully investigated in the future using other methodological approaches. As to the proportion of women's mandates in national parliaments, the effect is insignificant in statistical terms, but the meaning seems to indicate a negative effect posed by the positive correlation, i.e., a 1% increase in the proportion of mandates held by women in national parliaments (WP) led to an increase in primary energy consumption. The opposite, i.e., positive status, the effects of decreasing primary energy consumption by 0.10–0.15% and 0.01%, respectively, occurred due to the 1% increase in the share of the female population in the total population (FPOP), respectively the change in the share of health expenditure in GDP (H-GDP).

Most of the models are not auto correlated because Durbin–Watson is close to the value of two. They are also statistically relevant, and the amount of information recovered ranges from 20% to 78%.

4.2.2. Determinants of Final Energy Consumption

Another analysis was carried out on final energy consumption, with the aim of identifying variables that have a positive or negative influence on it. As in the previous cases, both economic variables and socio-ecological indicators of the holistic system were considered to best capture the relationships within it, the role of the energy sector and the evaluation of past policies. The results of the analysis based on Equation (2) are presented in Table 5.

Table 5. Results of multiple regressions regarding the percentage modification of final energy consumption.

	Dependent Variable: Percentage Change in Final Energy Consumption (FEC)						
Variables	**Model1**	**Model2**	**Model3**	**Model4**	**Model5**	**Model6**	**Model7**
Constant	0.0013	−0.0181 ***	−0.0114 ***	0.0007	0.0035	0.003	−0.0018
GDP		0.4576 ***	0.4904 ***				
GDP-2	1.8902 **	1.4775 **	−0.2468		1.1334		1.4974 **
GHG	0.7421 ***					0.5776 ***	0.5374 ***
RE		−0.0028 *		−0.0033 **		0.0011	
FFE			0.0073 ***		0.0064 ***		
NE		−0.0015 *					0.0002
EP		0.0693 **		0.0193 ***	0.0122 ($p = 0.113$)		
REL	0.0018 ***					0.0017 ***	0.0011 ***
K	0.0340 *						0.0508 **
K-GDP				0.0049 ***	0.0031 ***		
EIMP		−0.0003	−0.0011 *				
C-GDP	−0.0004 ***		−0.0003 ***	−0.0004 ***	−0.0003 ***	−0.0004 **	
SE-GDP	0.0001		0.0001 ($p = 0.106$)				
EB-GDP			−0.0018 *			−0.0031 ***	
M-GDP			−0.0191 *		−0.0124 *		
RD-GDP	0.0434 **		0.0812 ***	0.0151			
AA	0.0028 *			0.0035 **	0.0027 *	0.0031 **	
ENVT	−0.0181 **	−0.0188 **	−0.0273 ***	−0.0206 **			
POP		0.4518 **					
PD							−0.0015 **

Table 5. *Cont.*

	Dependent Variable: Percentage Change in Final Energy Consumption (FEC)						
Variables	**Model1**	**Model2**	**Model3**	**Model4**	**Model5**	**Model6**	**Model7**
UPOP				−0.0100			
WP		0.0009				0.0004	0.0004
WF			0.3461 ***	0.2909 ***			0.2355 **
TEDU		0.0012 *		0.0008		0.0001	
H-GDP			−0.0093 (p = 0.107)		−0.0101 *		
IU					0.0001		
Cross-sectional fixed effects	0.3326	0.6658	0.6372	0.3382	0.4572	0.1771	0.3782
Time fixed effects	3.0482 ***	10.63 ***	7.592 ***	11.8825 ***	10.5902 ***	4.3158 ***	4.2123 ***
Hausman test: Random cross-sectional effects	no	no	no	no	no	no	No
Hausman test: Random time effects	18.9495 **	29.0991 ***	19.0455 *	12.3588	7.9126	13.5853 (p = 0.145)	62.67666 ***
R-squared	65.53%	48.74%	55.00%	47.59%	15.19%	43.86%	51.97%
F-statistic	23.3540 ***	14.9225 ***	12.8999 ***	12.6450 ***	6.6479 ***	31.8689 ***	19.3905 ***
Durbin–Watson	2.41	2.35	2.44	2.34	2.1	2.6	2.06

Note: Statistical significance, *p*-value, * 10%, ** 5% or *** 1%. Source: [18].

The results of the final energy consumption determinants show both similarities and significant differences compared to those related to primary energy consumption.

In the case of GDP influences, the same linear trend of increasing the final energy consumption (FEC) was observed, but with the negative effect of 0.45–0.49%, which is approximately 10% higher than the primary energy consumption (PEC) case. In addition, ignoring statistical insignificance, model 3 even shows the hyperbola relationship between FEC and GDP. Similar effects to PEC occurred in the case of GHG emissions change (GHG), which 1% increases stimulated FEC growth by 0.53–0.74%, with a lower negative effect on PEC. This was somewhat expected, because the final energy consumption depends on the primary energy consumption.

In addition, the energy mix generated impact on the final energy consumption changes similar to those related to the change in primary energy consumption, except for the influence of the change in the share of nuclear energy consumption (NE), which generated statistically significant positive effect. Thus, the decrease of final energy consumption by 0.001% was caused by a 1% increase in NE. However, in the 7th model from Table 5, there is also a negative effect, statistically insignificant, which shows the necessity of further research. At the same time, both changes in fossil fuel consumption (FFE) as well as changes in the share of renewable energy in consumption (RE) have the same effects as in the primary energy determinants analysis: the negative effect of FFE caused the increase in FEC (0.006–0.007%) and the positive effect of RE generated decreases of FEC (−0.002–0.003%). In this case, the negative effect of the oil price change (EP) on the change in final energy consumption (FEC) contradicts the research hypothesis, according to which high oil prices cause a reduction in energy consumption. In this respect, the decrease of FEC by 0.019–0.069% occurred due to the increase in oil prices by 1%. This result can be explained by the diversification of the energy mix and the high possibilities of replacing oil with other energy sources.

Comparing the results in Table 4 with those in Table 5, it was found that there were identical results on the impact of some indicators on both primary and final energy consumption. These determinants with identical effects, previously interpreted, are as follows: Changes in net energy import (EIMP), changes in gross fixed capital formation (K-GDP), change in external balance (EB-GDP) and changes in health expenditure (H-GDP). At the same time, similar influences from capital stock changes (D_LOG_K) and commercial openness (SE-GDP) were observed. In the first case, the 1% increase in capital stock caused an increase of 0.03–0.05% in final energy consumption, the value being about half the value for primary energy consumption. In the second case, although a positive mathematical relationship was observed between SE-GDP and FEC, it generates a negative effect on the evolution of final energy consumption, but is not statistically significant.

What is interesting is the adverse impact of financial development on final energy consumption compared to primary energy consumption. Thus, the change in final energy consumption diminished with very low values of 0.0003–0.0004% amid a 1% improvement in financial development, thus indicating a positive effect on the trend of the endogenous variable at EU level during 1995–2014. This time, the research hypothesis was confirmed.

Contrary to the influence of primary energy consumption and the research hypothesis, the increase in the share of military expenditures in GDP (M-GDP) stimulated the reduction of the final energy consumption change by 0.01%, similar to the result recorded in the case of testing the regressions on GHG emissions. From the author's knowledge, there is no evidence of this relationship, but only the study by Jorgenson and Clark [56], which supports the increase of the ecological footprint by this indicator, i.e., the intensification of national consumption. An opposite effect on FEC, which once again rejects the research hypothesis, is caused by a change in the share of R & D expenditure, since improving it by 1% causes increases in final energy consumption by 0.04–0.08%.

Further, a 1% increase in the change of the share of the agricultural area (AA) led to an increase of the final energy consumption change by 0.003%, contrary to the influence on the primary energy consumption, but confirming the research hypothesis that the increase in agricultural area determines increased energy consumption as a result of agricultural activities. At the same time, a 1% increase of the share of environmental taxes in GDP (ENVT) generated final energy savings between 0.01% and 0.02%, which confirms the research hypothesis.

Last but not least, the influence of the social variables on the final consumption of energy, which are similar to the effects of the primary energy consumption, were tested, except for the change in the population density, which, this time, inversely influences the endogenous variable, inducing a decrease in the final energy consumption with 0.0015%, contrary to the research hypothesis. However, strong impacts were identified in population change (POP) and labour change (WF). Thus, a population increase of 1% caused the final energy consumption to increase by 0.45%, while the increase of the labour force change by 1% caused the increase of the final energy consumption change by 0.23–0.34%. Another increase in the change in final energy consumption was caused by the increase in the share of the labour force with tertiary education in the total population (TEDU), the increase being about 0.001%. Although the research hypothesis is rejected, energy consumption has increased in this case, probably because of higher social welfare than other social categories, which induces the use of more energy-consuming equipment and technologies. The last tested variables do not present statistically significant values of the coefficients, but they can be interpreted in terms of meaning and influence they could have on final energy consumption. Thus, the increase of the proportion of women's mandates in national parliaments (WP) and the growth of Internet users (IU) appear to have increased final energy consumption. However, the existence of low values is noted, therefore, even if the effect would have been statistically relevant, the influence would have been almost insignificant.

Finally, the models estimated in Table 5 are statistically relevant according to the F Test. In terms of the Durbin–Watson test, which does not indicate autocorrelation for values close to two, the analysed models do not exhibit autocorrelation or, if present, cannot be determined by the Eviews software. The amount of information recovered is between 15% and 65%.

5. Discussion

Some studies [17] confirm the existence of a concave relationship between the economic development and the degradation of the natural environment, according to Kuznets' curve evolution, also a positive relationship is proven by other studies [22,23], while others [32,61] invalidate this relationship. Similarly, there are studies on the social dimension [3,36,60], which show that improving the conditions of the natural environment contributes directly to the improvement of social and institutional performance, components that are part of the social system of society. At the same time, the causality between economic development and social performance is shown, but the sign of the relationship is not conclusive [61]. Of course, in all these records, the role of the energy sector is undoubtedly important in mitigating climate change.

One of the purposes of the research was to analyse the factors of influence of energy consumption at EU28 level between 1995 and 2014. Several types of energy consumption were considered: The primary energy consumption and the final energy consumption. The models generated relevant information for both national and European policy makers as well as for the scientific literature on energy.

Table 6 summarizes the results of the analysis of the determinants of the endogenous variables considered.

First, the determinants with a strongly significant impact on the evolution of primary energy consumption are as follows: GHG emissions, GDP, size of human population and labour, capital accumulations and human feminine population. These strong influence factors have shown a positive relationship with primary energy consumption, with the exception of the human feminine population that has a negative relationship with the endogenous variable, which means that in the case of the EU28 the increase in the female population weight leads to a decrease of the energy consumption, thus stimulating the improvement of the state of the holistic system.

Table 6. Summary of the energy consumption determinants in EU 28, 1995–2014.

Independent Variables	Dependent Variables	
	PEC	FEC
GHG	+	+
GDP	+	+
GDP-2	+	+
FFE	+	+
RE	−	−
NE	+	−
EP	+	+
REL	−	+
NEL	+	
K	+	+
K-GDP	+	+
EIMP	≈	−
C-GDP	+	−
SE-GDP	!!	!!
EB-GDP	−	−
M-GDP	!!	−
RD-GDP	+	+
IU	+	!!
AA	≈	+
ENVT	!!	−
NR-GDP	+	
POP	+	+
PD	+	+
UPOP	+	!!
FPOP	−	
FM	+	
WP	!!	!!
WF	+	+
TEDU	!!	+
H-GDP	−	−

Note: Statistically significant relationship between endogenous and exogenous are denoted as follows: Positive + or negative −; ≈ Inconclusive relationship; !! Statistical insignificance. Source: [18].

In addition to the factors with a strong impact on the evolution of primary energy consumption, other determinants have also been analysed which have a very low influence on the endogenous variable. The latter recorded a positive relationship with the consumption of fossil fuels and nuclear energy, the oil price, the financial development, the research and development expenditures, the depletion of natural resources, the degree of urbanization, the population density, female decision makers and the number of Internet users.

By considering the negative impact of these factors on energy consumption, in the sense that it stimulates its increase, the policies should integrate sustainable principles and objectives of reducing them while increasing the social welfare. For example, while [59] indicate positive influence of financial development on reducing environmental impact, our results suggest an intensification of the energy consumption at EU level. In this case, as [59] states, financial developed countries benefit of innovative technologies and financial networks, which on long term stimulate diminution of environmental degradation. Although, initially, energy consumption and other use of resources could increase, the investments in green technologies are one of the best options for tackling climate change on long term. At the same time, being consistent with the findings of [43], the energy price rises seem to slowly intensify the energy consumption, which means that increasing the oil prices are not necessarily reducing the environmental impact. However, maybe aiming to stimulate the green initiative are more effective ways of tackling climate change. Further, the urbanization degree should be diminished by developing the sectors of health, education and services in rural area, as well as creating fast linked infrastructure with the urban and peri-urban areas. In another example, the number of internet users would most likely increase in the future; however, technological development should focus on improving energy efficiency and energy use in production, transportation and consumption of these equipment and tools. In addition, although the proportion of women's mandates in national parliaments is a statistically insignificant determinant of energy consumption, its positive sign, along with that of women decision makers, indicate small intensification of energy consumption. While [59] found out that both the gender and the politic involvement of women influence the energy policies voting, the main influencing factor being the party affiliation, it seems like changing the views of the politic groups towards more green initiatives is more important.

In the same time, it was registered a negative relationship between primary energy consumption and the external balance of goods and services, the consumption of renewable energies and the health care expenditures, emphasizing the stimulation of the reduction in energy consumption. In this case, a policy measure should give, for example, tax reduction or other financial stimulus for reducing the energy consumption on all levels, as the traditional economic models of development and those based on consumption are not sustainable and intensify climate change. So, the developing countries should focus on not applying the pathways of developed countries, as Earth is already overstressed.

Then, a slightly different situation has been demonstrated in the impact of the final energy consumption determinants, which are statistically significant and more congenial in relation to the primary energy consumption factors. Again, the determinants with a strong statistically significant impact on the evolution of final energy consumption are as follows: GHG emissions, GDP, human population and labour, oil prices, R & D expenditure, capital accumulations and environmental taxes. Of these, with the exception of environmental taxes, all determinants had a positive relationship with final energy consumption, which means that in the case of the EU28 most of the high impact factors cause the intensification of the final energy consumption, which led, as a whole, the worsening of the state of the holistic system. It seems like policies which increase the environmental taxes stimulate the reduction of energy and, further, the climate change mitigation.

For assessing the macroeconomic perspective, it is also important to focus at microeconomic level, mainly at the factors that affect the decision to be friendly environmental and to invest in proper equipment. One of the factors that stimulate the green investments seems to be the length of the firm-bank relationship [67]. Other characteristics that encourage the green investment are related with the size, the age, the profitability and the innovative feature of the entity. It seems that more of these encourage entities to have a higher probability for investing in environmentally friendly equipment [67]. The problem regarding this type of information is that data on individual European EU firms are rare and incomplete and so, further studies should focus on it. The studies should look at the process of transforming micro-data into macro level observations in order to provide reliable information (for example R & D seems to encourage green equipment development, so smaller consumption of energy, while at macro level, the R & D expenditure from GDP seems to increase both the primary and the final consumption of energy). In Italy, facilitating the financing in green investment could create a win–win relationship for the environmental protection and it could provide long term values in features related with innovations, job opportunities or other social incentives [68]. On the other hand, uncertainty about the government policies, short term perspective of financial instruments and the lack of financial tailored to small-scale investment needs mitigates the effect of green financing opportunities. At the macroeconomic level, the growth of the economy has the highest net gain from a system where the stock market, mainly market capitalization of listed domestic entities, renewable energy-measured by shares of renewable energy in total final energy consumption-and non-hydro renewable electricity net generation, foreign direct investment inflows in GDP, domestic credit provided by financial sector in GDP, the Brent oil spot price and total greenhouse gas emissions are included [69]. Moreover, among the net determinants of the share of renewable energy are the credit market and the stock market. In China, fluctuations on oil prices also influence the energy structure. Considering the importance of oil prices' fluctuations, options could be used to reduce the volatility of it and to quantify the benefit of using an active strategic reverse for volatility's mitigation [70].

In addition to the factors with a strong impact on the evolution of final energy consumption, other determinants have also been analysed which have a very low influence on the endogenous variable. Of these, fossil fuel consumption, agricultural land change, population density and tertiary education have led to increased final energy consumption, while renewable energy, nuclear power consumption, financial openness, net energy imports, the balance of external goods and services, military spending, and healthcare spending have led to a decline in final energy consumption. Future studies should also be developed to retest the impact of urbanization, commercial openness, internet users and women's influence in national parliaments on the evolution of final energy consumption at EU28 level as research has not produced conclusive findings in these cases.

Moreover, some variables registered statistical insignificance in relation with one type of energy consumption, such as military expenditures, internet users, environmental taxes, urbanisation and the tertiary education, as well as with the both types of endogenous variables analysed, such as trade openness and women in leading position. Although the military expenditure and environmental taxes stimulated the diminution of the finale energy consumption at EU level during 1995–2014, in terms of its correlation with primary energy consumption, it seems like statistical insignificance and mixed results are recorded. While the number of internet users, respectively the people with tertiary education, seems to increase the PEC, respectively the FEC, their effect on FEC and PEC is statistically insignificant, but with the same positive sign. These results are interesting as they indicate a higher use of energy when increasing the technological and the educational levels. Contrarily, while the increase of the urban population seems to increase the PEC, its effect on FEC is statistically insignificant, but with a negative sign, which means that the increase of urban population generated a diminution of the final energy consumption. This mixed result could be explained by the fact that, in the urban areas, the accommodations are smaller, being more apartments, which might consume less energy while the houses on rural areas could consume more energy. Statistically insignificant and with low impact, the trade openness seems to increase both types of energy consumption, based on the positive sign of its coefficients, such as in the models 1, 3 and 10. Similarly, the women in leading position seem to increase the energy consumption at the EU level, although some studies [71] show that their involvement seems to bring more environmental-friendly practices. Regarding the analysis conducted, it has been noticed that the combinations of factors influence differently the magnitude and sometimes the direction of the impacts of the determinants analysed on the endogenous variables and thus there is a methodological limitation of the research given that the multiple regressions do not allow the introduction of all available variables to evaluate the performance of the holistic system in a single model, because their effects would cancel each other out because of the lack of independence. However, the validity and diversity of results remains equally important to substantiate the need to improve both integrated and environmental energy policies. Nevertheless, it is proposed to carry out further analyses to apply new mathematical models based on complexity, such as those proposed by Marczyk [72] in the field of energy, as they allow the cumulative consideration of all available variables of a complex system, so such as the energy sector.

6. Conclusions

The relationship between economic, social and environmental factors, as a holistic system, and the consumption of energy (both primary and final) poses great interest for researchers around the world, the Chinese and Turkish researchers proving a remarkable amount of work placed in this field, but also for the authorities since reducing the non-renewable energy consumption is one of the UN sustainable development goals [12]. In addition, the scientific publication in this field has increased in the past years; the more the effects of climate change are becoming more obvious.

The panel models were conducted at EU level during 1995–2014 to estimate the determinants and their impact on both primary and final energy consumption. On one hand, it seems like the energy consumption is stimulated by increasing the GHG emissions, GDP, the use of fossil fuel sources, the oil price, the capital stock, research and development expenditures, agricultural area, natural resource depletion, the population and its density, as well as the labour force. On other hand, it seems like the energy consumption is diminished by increasing health expenditures, the female population, the external balance of goods and services, environmental taxes, as well as renewable energies. Thus, the decision makers on both a regional and a country level should focus on these results for introducing into the public policies the reduction of the determinants which increase the energy consumption for climate change mitigation by using punitive measures, while promoting the sustainable practices for better understanding of the impact at both individual and society levels.

Most of the models proposed in this study include a wider set of variables from those present in the literature, some of which have not been tested so far. Thus, this research is important because it indicated many historical trends of the components of the social, economic and environmental dimensions, which must be considered in future sustainable energy policies as well as in setting new targets and collaboration in the integrated energy-climate field. In the future, it is proposed to continue the research by studying the variables at each state level together with integration of the national energy policies. In conclusion, the study supports decision-makers in evaluating energy policies in the context of sustainability requirements by providing analyses of the determinants of energy consumption.

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Article

Interrelation between Eco-Innovation and Intra-Industry Trade—A Proposal for a Proxy Indicator of Sustainability in the EU Countries

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Abstract: The "innovation–trade" interrelation has been a subject of research for decades. Nowadays, in the context of the growing importance of sustainable development, the role of eco-innovation is essential for promoting a rapid economic growth in each country. In this sense, eco-innovation influences the level of intra-industry trade stimulating international trade to adopt environmentally-friendly technologies. In general, the evaluation of eco-innovation in EU countries is done through indicators of their degree of performance and their impact on the welfare of nations. Using Eurostat data and WITS (World Integrated Trade Solution) database for the period 2010–2018, the authors of this paper give empirical evidence of a linkage between the two indicators. The Grubel–Lloyd index is selected as an appropriate tool to show that socio-economic performance has a significant weight in eco-innovation scoreboard measurement. The results confirm that intra-industry trade of each EU country is closely related to the level of its eco-innovation index. To our knowledge, this is the first attempt to test for such a type of interrelation and to show that by verifying the usefulness of eco-innovation performance in EU countries through an intra-industry trade indicator (IIT) such as the Grubel–Lloyd index.

Keywords: eco-innovation; Grubel–Lloyd index; intra-industry trade; European Union countries

JEL Classification: D91; L10; O10; O57; P20; P52

1. Introduction

Eco-innovation is a concept of great importance to business and policy makers, which covers many innovations of environmental benefit [1]. Eco-innovation is defined as any form of innovation aiming at a significant and demonstrable advancement towards the goal of sustainable development, through reducing the impacts on the environment or achieving an efficient and responsible use of resources, including both intended and unintended environmental effects from innovation, as well as not only environmental technology but also processes, systems and services [2]. Eco-innovation is becoming an indispensable tool for stimulating efficiency in the use of resources. However, to promote eco-innovation initiatives, the new economic investment needed at the local and national level is the support for research, information and education of both businesses and consumers. All the aforementioned actions can contribute towards the overcoming of the main barriers to eco-innovations by achieving an efficient use of resources, by increasing investments and by ensuring that all relevant policies influence the efficiency of resources in a balanced manner. Currently the European Union recognises eco-innovation as the main driver for sustainable development, and for this reason it has developed a specific indicator that can measure the level of eco-innovation: the Eco-Innovation Scoreboard (Eco-IS). This tool, developed by the European Eco-Innovation Observatory (EIO), allows for the evaluation of the performance of European countries and the comparison between the results obtained, outlining strengths and weaknesses. The Eco-IS consists of 16 indicators that are grouped into five separate components: (1) eco-innovation inputs (R&D appropriations, staff and researchers and green investments in early stages); (2) eco-innovation activities (companies that have implemented innovation activities aimed at reducing material and supplying energy per unit of output); (3) eco-innovation output (measured through patents, publications and media coverage); (4) environmental results (i.e., the benefits to the environment assessed with reference to the "productivity" of materials, energy and water, together with the "intensity" of greenhouse gas emissions); and (5) socio-economic results (based on performance data of "eco-industries", including those relating to exports, employments and turnover). Obviously, the assessment of eco-innovation results is a set of different indicators. This creates opportunities for new interrelations or impact assessments. On the one hand, improving the quality of technology in the field of ecology is associated with increased income, with the growing turnovers. On the other hand, economic progress based on environmental improvement is unthinkable without the openness of the economy to trade, exchange or investment. In both cases, the cooperation is an encouraging trade policy instrument. Trade cooperation between European Union Member States is based mainly on the intra-industry trade (IIT) [3]. IIT takes place when goods from the same sector are traded in both directions. Thus, the more similar two countries are, the more their trade develops towards IIT. Spulber (2008) [4] counted intra-industry trade as one of the most important properties of technological progress in international trade, as the expected variety of goods traded in equilibrium increases when innovative technology trade increases, thus the countries draw benefits from intra-industry trade [4]. IIT in intra-regional trade has higher increases than that in inter-regional trade (inter-industry trade is defined as trade between two countries where the goods are from different sectors). This situation is valid for EU countries and comes as a consequence of the European integration process [5].

In the last decades, IIT has also been used for other purposes. For measuring eco-innovations, no single method or indicator is likely to be sufficient. In this paper, we discuss the role of the IIT as an alternative indicator for eco-innovation performance in EU countries. The relationship between trade and the environment, and the role of IIT have become increasingly important. In the literature, it is reported that the growth in international trade is characterised by intensive pollution [6]. The main role of the Grubel–Lloyd Index is to validate and verify if there is intra-industry trade or no inter-industry of a particular product among countries. In our paper, the authors validate and verify whether the Grubel–Lloyd Index is a proxy indicator of the eco-index. Despite the widespread view over the years, the description of the IIT measures has had little effect on the environment; the sustainability efforts of modern society require that a new evidence and literature approach be explored. Our study has investigated the linkages between the eco-innovations and the magnitude in intra-industry trade between EU countries for the period 2010–2018. Our goal is to verify the validity of the eco-index through another one, using a reliable and well-established index such as the Grubel–Lloyd index. We adopted the idea to promote the alternative usage of an old and well known index as the Grubel–Lloyd index, the use of which would not create additional obstacles for researchers. The authors' thesis is that the Grubel–Lloyd index is applicable to all sectors, whether or not they pollute the environment. The interrelation between the eco-innovation index and intra-industry trade can gather more information about sustainability and make credible and transparent policy-making decisions about the eco-innovative future policy of each country. For this purpose, we used the Grubel–Lloyd index as a measure of IIT. The paper is organised as follows: Section 2 describes the existing relevant literature. Section 3 provides stylised facts on the eco-innovation index by Eurostat for the period 2010–2018, by country and by periods. We present the Grubel–Lloyd indexes calculated on data from WITS (COMtrade) database, split on SITC Revision 1, one-digit ("Section") and two-digit

("Division") per year and per country. Finally, an empirical evidence of the linkage between the eco-innovation index and the average Grubel–Lloyd values for different years, is presented.

2. Literature Review

Links between trade and sustainability naturally draw from international trade theory [7]. Trade may increase pollution and in the same time trade restrictions can reduce pollution. A weakening of environmental policy will increase a country's net export of polluting goods and will help domestic firms to compete with their foreign rivals. According to the Porter hypothesis, the environmental regulation stimulates technological innovation and thereby has positive effects on both the economy and the environment [8]. International trade has always been considered as a channel for transfer of technology from industrial to relatively less developed countries [9,10]. The development of the sustainability concept over the last decades has also made its requirements on trade indexes. The Heckscher–Ohlin–Samuelson (HOS) model is the natural starting point for exploring sustainability. In 1975, Grubel and Lloyd published a paper which stimulated multiple studies in the field of intra-industry trade (IIT). The concept of the authors is based on the HOS model for similar factor endowments and the increasing level of integration between European countries. Over time, the index has developed further to encompass the influence of factors such as trade costs, investment costs, and production [11]. Furthermore, it has become necessary to calculate indicators that reflect the ecological state of each or group of countries in terms of their technological progress and trade policy. Since the seminal Grubel and Lloyd paper (1975) [12], a vast literature on IIT has emerged (for reviews see Ambroziak (2012) [13] and Greenaway and Milner (2005) [14]). Vertically differentiated IIT models step on various versions of the classical Heckscher–Ohlin model, while horizontally differentiated IIT is modelled mostly under monopolistic competition theories, initiated by Dixit and Stiglitz in 1977 [15]. Vertical IIT is the dominant type of trade [16]. For example, for Europe [17], Fontagne et al. investigated in 1998 the nature of trade flows for 1980–1994, demonstrating that there exists a positive link between vertical IIT and horizontal IIT, and that vertical IIT strongly predominates [17]. Different studies demonstrate the effects of levels of aggregation on IIT indexes, emphasising the disentangling of vertical and horizontal intra-industry trade as a great step forward [18]. These studies have the potential to be a basis for the development of eco-innovative techniques and other environment sensitive innovations. Only recently, there have been attempts to specifically measure eco-innovations. The main problem with eco-innovations is their multifaceted nature, therefore multiple approaches have been proposed. As emphasised in Arundel (2009) [1], no single method or indicator is likely to be sufficient to measure eco-innovation. The most widely known are the results of the MEI project (Measuring Eco-Innovation) of the EU and the OECD workshop on greening regional trade agreements.The MEI classification of eco-innovations is: environmental technologies, organisational innovation, product and service innovation, green system innovations. Measuring has been proposed applying survey analysis, patent analysis, and digital and documentary source analysis [19]. Recent studies by Cherniwchan in 2017 and Cherniwchan et al., also in 2017, focus on developing a theory on the links between trade and environment [20,21]. Trade as an indicator for eco-innovation has been used only in limited areas—"Eco-industry, its size, employment, perspectives, and barriers to growth in an enlarged EU" made for DG Environment in 2006 [22] represents an information guideline about exports and imports in selected eco-industry sectors. A crucial question is whether trade in polluting goods is intra-industry, or is driven by comparative advantage. There is little evidence that polluting goods production has shifted towards low-income countries due to trade liberalisation, but there is some evidence that exporters are cleaner than other firms.The inclusion of eco-innovations into the scope of intra-industry trade (IIT) research helps to expand the scope of study of both international trade and intranational trade. There is vast literature on trade liberalisation and the environment, with some publications focusing on IIT. Over the years, different authors have been discussing the interrelation between eco-innovations and intra-industry trade in search of better environmental management solutions for countries or regions. However, the usefulness of a specific index as a precise and accurate one has not been calculated. Therefore, the views of some authors closest to the topic of this study are presented. According to J. Roy (2017) [6], the empirical examination of IIT and the environment is overdue and/or relatively unexplored. The increasing interest in greenhouse gas emissions, energy consumption, pollution-intensive industries, etc. over the last years has determined the growing interest in the ecological impact–IIT demand relationship. In the literature, there has been a discussion on trans-border pollution [23,24], but the centre of the debate was around the North–South division. Aralas and Hoehn's analysis of 2010 [25] suggests that greater openness to trade or increased liberalisation of trade leads to lower levels of emissions and therefore is beneficial to the environment.The deepening European economic integration fosters IIT, especially in Eastern European countries, where the existence of fluctuations in IIT indexes is quite evident [26]. Other studies are linked with the attempt of modelling the optimal tax policies and policy reforms in the presence of trans-border pollution [27], as well as studies of the optimal subsidies issue [24]. Using the data of the Environmental Performance Index of the World Bank and the UN Commodity Trade Database of UN Comtrade for more than 200 countries, Roy (2017) concluded that IIT is typically characterised by a positive impact on the environment. IIT is undoubtedly more pro-environment than overall trade. Fung and Maechler (2007) [28] found that the impact depends on the nature of pollution (local, transboundary or global) and on the type of the country which liberalises trade; accordingly, the environmental effects are not necessarily negative. Benarroch and Weder (2006) [29] in their overview also found that increased output need not come at the cost of a higher pollution. Jo et al. (2015) [30] also considered the positive linkage between eco-innovation and technologies as a motivation for trade and socio-economic development. If eco-innovation incorporates new technologies in favour of the market, for example green products, the economy of each country evolves thanks to sustainable industrial systems. The authors called this effect "the ripple effect for sustainability" [30]. The report of Sweden's Globalisation council (2009) [31] also studies the effects of trade on the environment. Some evidence of this report suggests that trade and growth can exacerbate other measures of environmental degradation, particularly CO_2 emissions (carbon dioxide). In environmental policy studies, there is some evidence that tighter environmental standards at home can lead to less emissions abroad [32]. At the same time, it is emphasised that no single country can address global environmental problems on its own, due to the freerider problem. Thus, environmental policy requires international cooperation, and international trade puts significant downward and upward pressure on ecological issues. To summarise, environmental issues in connection with IIT have rarely been studied. There are some attempts to use IIT as a proxy for other indicators— i.e., measures for the change of IIT are mainly used as indicators for labor adjustment [33]. This has made the current research relevant and useful to researchers in both the eco-innovation and trade area of studies.

3. Methodology and Data

The intention of this study was to make a proof-of-concept of the possibility to use the IIT as a proxy for eco-innovation measures. The methodology includes the following steps. Firstly, we collected data from Eurostat for the eco-indexes (Eco-Innovation Scoreboard, Eco-IS) for all EU countries. We utilised the Eurostat eco-innovation index to show how well each individual Member State performs in eco-innovations, as compared to the EU average. As the EU-28 average index is equal to 100, the value for each country depends on the relevant components(eco-innovation input, eco-innovation activities, eco-innovation output, environmental results and socio-economic results). Based on these data, we calculated a standard deviation of eco-indexes per country and per year. The degree of variation of the index allows predicting which countries would be potentially problematic in their eco-innovation performance. Other necessary data for our research are the import–export data (in thousands of dollars) from WITS (COMtrade) database of UN for the EU-28 countries. We utilised SITC Revision 1 classification, with one-digit level of aggregation ("Section") per year and per country, because it represents the most recognisable and used nomenclature of goods. This nomenclature includes the following groups: food and live animals, beverage and tobacco, crude materials and fuels, mineral fuels and relevant materials, animal and vegetable oils and fats, manufactured goods classified chiefly by material, machinery and transport equipment, miscellaneous manufactured goods, commodities and other (not class) goods. All data were selected for the period 2010–2018 for the above-mentioned 10 sectors. Further, we extended the research for two-digit level ("Division"), comprising 60 sectors. In fact, we have a "mirror" database for the trade of each EU country, or in other words one country (Reporter country) has 27 trading partners and each of these partners have counter-standing trade position for this country. Furthermore, in our study, we utilised the classical Grubel–Lloyd formula, according to the data for the export of each EU country:

$$GL = 1 - \frac{\sum_{k=1}^{n} |X_k - M_k|}{\sum_{k=1}^{n} (X_k + M_k)} \tag{1}$$

where X_k and M_k are respectively the export and the import of the k-th sector.

We utilised the Grubel–Lloyd index as a measure of proximity in the countries' technology levels. Values closer to 1 indicate a bigger share of intra-industry trade (IIT) between countries, and vice versa. Intra-industry trade, also called two-way trade, consists of simultaneous import and export of products (including assemblies, subassemblies and components) coming from the same industry, which are close substitutes in the sphere of consumption, production, or in both areas [12].

The first IIT index was proposed by Balassa (1966) [34], later the major developments were made by Grubel and Lloyd (1975) [12], which is the most important contribution in the area. During the years, different authors, such as Aquino in 1978 [35], Henao-Rodrigez et al. in 2016 [36], Brulhart in 2009 [37], Greenaway in 1983 [38], Hamilton and Kniest in 1991 [39], Siggel in 2006 [40] and Glejser, Goossens and Eede in 1982 [41], made good overviews of measurement issues of IIT. When the Grubel–Lloyd index (GL) varies to -, it indicates pure inter-industry trade and when the index varies to 1, it indicates pure intra-industry trade. We calculate the average meaning of the GL indexes per country, per year. The average meaning represents a value for the country as a whole, thus the trade strengths with a specific commodity are eliminated (presumably, each country has its own natural, socio-economic or other advantages). The next step of our study was to make a regression of the average values of GL indexes with the eco-indexes in order to search for p-values < 0.05 in the ordinary least squares model (OLS). P-values show whether there is an interrelation between the values of the GL index and the eco-index. If there is an interrelation, we assume that we can use the GL rather than the eco-index, because it shows the eco-index validity. In this sense, the level of intra-industry trade between countries coincides with their ecological orientation. The more developed countries are expected to have more predominant intra-industry trade (IIT), and vice versa. IIT is a suggestive hint for the degree of technological development of the countries and acts also for a driver of their environmental development. We observed also R^2 value to be equal to or greater than 0.10, as suggested by Falk and Miller in 1992 [42]. The final step of our study was the clusterisation process, which served for grouping of countries and offered an initial benchmark for their eco-innovation level. On the basis of the Eco-Scoreboard (Eco-IS) database, we positioned the countries both in space (28 EU countries in the 8-dimensional space, according to the number of years relevant to this study) and in time (9 years in the 28-dimensional space, according to the number of countries). The purpose of the clusterisation was to find out whether the EU-28 countries differ in their environmental progress per year. Through the calculations made for the period 2010–2018, we prove the existing interrelation between eco-innovation and technological level in the EU-28 countries, as well as analyse the interaction between the two utilised indexes.

4. Results

To illustrate the groups of countries within the EU, we start with two dendrograms which represent the eco-innovation index of the 28 Member States of the European Union. The first dendrogram features two sub-clusters that outline the differences in eco-innovation levels in Europe (Figure 1). In clusterising the countries per values of the index in periods, the "East–West" division becomes very clearly visible. East European countries have traditionally less eco incentives, and thus the values of the eco-innovation index are lower in general. Thus, the situation for the 1990s, when the East European countries did not participate in international trade and generally lacked incentives, continues to be a particularity 20–30 years later. Environmental consequences are reminiscent of the situation in West European countries one or two generations ago [43].

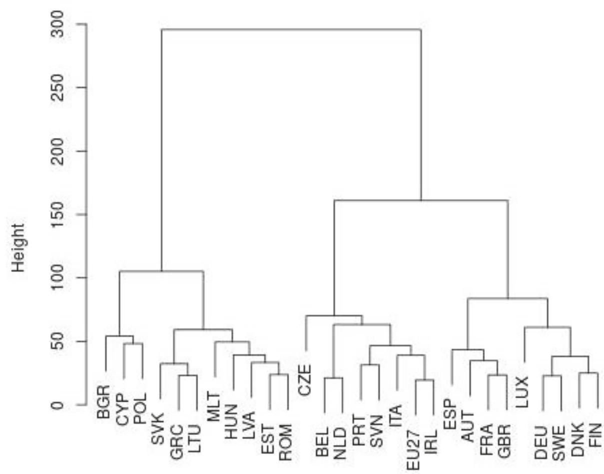

Figure 1. Eco-innovation levels in EU, 2010–2018. Source: Own calculations based on Eurostat data.

By observing the clusterisation diagram (Figure 2) of the eco-innovation index, with the clusterisation made across the countries' dimension, we can also clearly distinguish between the two halves of the period—2010–2013, and 2014–2018, respectively. The main deviations are in 2010 and in 2013, as the first one can be related to the global financial crisis and the second with the recovery from the effects of the financial crisis including the delays in investing in eco-innovations. The clusterisation is in line with findings of other studies [44] that, during a crisis, the part of productivity growth which comes as a result of eco-innovations is reduced.

Our findings show that splitting the clusterisation in two—i.e., for 2010–2013 and 2014–2018—does not change the groups of countries significantly. Countries do not move substantially between sub-clusters, they tend to remain in their initial places in general.

The clusterisation diagrams (available on demand) of the eco-index for the EU countries show that countries such as Germany, Sweden and Finland in the periods 2010–2013 and 2014–2018 sustained their levels of the index. The eco-index values for those countries, which traditionally invest in eco-innovations, are also high. The comparison for the same two periods of the eco-index values of countries such as Bulgaria, Romania and Croatia shows instability and low levels, which is linked to the low investment in eco-innovation in these countries.

Further, we considered the standard deviations of the index, per country (see Figure 3).

The highest fluctuation of the value is for Bulgaria, followed by other relatively poor countries. The lack of experience in eco-innovation activities can be a plausible explanation for the relatively high standard deviation of the index. The lowest values are observed in the most developed countries—Germany and the Scandinavian countries—where the eco-oriented policies have been applied for many decades.

Next, we continue with the Grubel–Lloyd index.

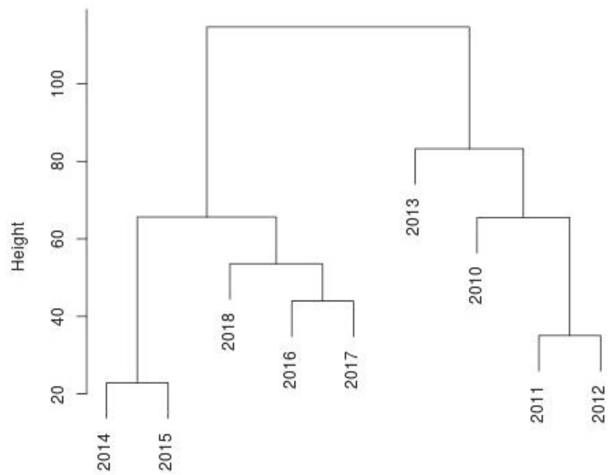

Figure 2. Eco-innovation levels in EU, by period. Source: Own calculations based on Eurostat data.

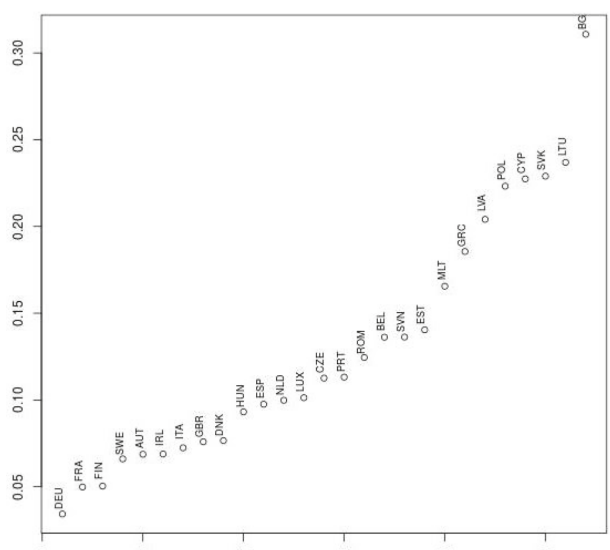

Figure 3. Standard deviations of the eco-innovation index. Source: Own calculations based on WITS data.

We wanted to check the fundamental ability of IIT to be a proxy for the eco-innovations, therefore we used data for the EU countries. In this way, we wanted to handle the "data existence and quality" problem—for many countries, the data for eco-innovations are either unavailable or incomplete, or both.

We consider EU data suitable for our study, because of the relative comparability between the country data and the relatively wide sample, with regions including countries of different technology, climate and income.

For our purpose, the data for 2010–2018 were retrieved from the WITS (Comtrade) database. We took exports and imports in USD, mirror data for the 28 countries, split on SITC Revision 1, one-digit ("Section") and two-digit ("Division") level of aggregation. We utilised data for 2010–2018, i.e., for one-digit 2017 data, we took 7547 export/import pairs, for 2016, 7560 pairs, etc. We consider such division of data as informative enough, since our goal is to make a "proof-of-concept" study. Furthermore, the literature on VIIT vs. HIIT (vertical vs. horizontal IIT) suggests that HIIT is a relatively rare case, even between EU countries, and the "Section" division captures VIIT quite well.

We calculated the bilateral GL-indexes and also the average values per country per year (Table 1 represents the calculations for 2017 only; others are available on request from the authors). The data (Table 1) confirm that IIT is large for the trade between countries with relatively similar profiles (income per capita, consumers with similar demand, etc.). For example, Estonian GL-indexes have relatively big values for Finland (0.72, similar language and traditions) and for several countries with similar (totalitarian) past and income—Bulgaria (0.78), Romania (0.74), Lithuania (0.64), Latvia (0.69) and Portugal (0.61)—unlike for Luxembourg (0.05).

Table 1. IIT Grubel–Lloyd indexes for 2017 EU-28. Source: Own calculations based on WITS data.

	AUT	BEL	BGR	CYP	CZE	DEU	DNK	ESP	EST	FIN	FRA	GBR	GRC	HRV	HUN	IRL	ITA	LTU	LUX	LVA	MLT	NLD	POL	PRT	ROM	SVK	SVN
BEL	0.81																										
BGR	0.7	0.49																									
CYP	0.43	0.58	0.5																								
CZE	0.78	0.62	0.75	0.09																							
DEU	0.86	0.75	0.72	0.06	0.76																						
DNK	0.77	0.64	0.69	0.4	0.62	0.7																					
ESP	0.84	0.74	0.56	0.05	0.56	0.72	0.83																				
EST	0.44	0.56	0.78	0.09	0.49	0.47	0.56	0.46																			
FIN	0.76	0.59	0.6	0.2	0.5	0.61	0.59	0.6	0.72																		
FRA	0.79	0.71	0.75	0.15	0.55	0.77	0.81	0.85	0.58	0.59																	
GBR	0.76	0.62	0.67	0.26	0.56	0.54	0.71	0.63	0.47	0.52	0.76																
GRC	0.54	0.29	0.82	0.09	0.61	0.54	0.36	0.45	0.52	0.53	0.45	0.62															
HRV	0.63	0.51	0.65	0.04	0.44	0.62	0.51	0.31	0.58	0.68	0.59	0.7	0.76														
HUN	0.81	0.68	0.54	0.07	0.78	0.86	0.82	0.68	0.2	0.65	0.76	0.59	0.48	0.48													
IRL	0.56	0.2	0.32	0.28	0.66	0.52	0.75	0.6	0.39	0.49	0.42	0.76	0.21	0.72	0.49												
ITA	0.82	0.82	0.73	0.06	0.79	0.83	0.7	0.85	0.38	0.55	0.78	0.68	0.6	0.68	0.79	0. 58											
LTU	0.48	0.58	0.72	0.19	0.6	0.61	0.54	0.78	0.64	0.69	0.59	0.49	0.46	0.5	0.62	0 .47	0.5										
LUX	0.58	0.51	0.12	0	0.59	0.66	0.44	0.72	0.05	0.45	0.73	0.64	0.22	0.67	0.7	0.3 6	0.64	0.34									
LVA	0.28	0.34	0.58	0.06	0.48	0.54	0.57	0.63	0.69	0.48	0.51	0.25	0.81	0.46	0.41	0.15	0.35	0.84	0.35								
MLT	0.44	0.49	0.55	0.47	0.21	0.58	0.13	0.38	0.07	0.16	0.68	0.45	0.18	0.18	0.65	0.36	0.36	0.42	0.58	0.31							
NLD	0.75	0.81	0.68	0.12	0.69	0.77	0.77	0.77	0.44	0.54	0.77	0.58	0.4	0.55	0.81	0.53	0.64	0.61	0.63	0.58	0.26						
POL	0.78	0.69	0.63	0.21	0.83	0.85	0.73	0.83	0.42	0.77	0.78	0.58	0.73	0.42	0.79	0.52	0.8	0.6	0.64	0.5	0.32	0.76					
PRT	0.55	0.7	0.62	0.13	0.7	0.7	0.46	0.72	0.61	0.45	0.72	0.64	0.65	0.57	0.62	0. 4	0.55	0.55	0.45	0.55	0.19	0.68	0.74				
ROM	0.66	0.7	0.73	0.32	0.87	0.84	0.55	0.81	0.74	0.63	0.77	0.6	0.72	0.68	0.71	0.3	0.74	0.63	0.37	0.47	0.07	0.67	0.64	0.31			
SVK	0.81	0.76	0.6	0.04	0.69	0.82	0.53	0.5	0.37	0.38	0.7	0.33	0.39	0.51	0.7	0.64	0.78	0.59	0.47	0.38	0.26	0.76	0.78	0.76	0.76		
SVN	0.8	0.67	0.54	0.18	0.77	0.77	0.49	0.78	0.45	0.6	0.73	0.71	0.77	0.76	0.85	0.4	0.74	0.33	0.56	0.31	0.21	0.7	0.77	0.56	0.73	0.73	
SWE	0.8	0.75	0.7	0.79	0.58	0.62	0.71	0.74	0.51	0.84	0.81	0.73	0.49	0.85	0.49	0.52	0.75	0.59	0.49	0.58	0.17	0.78	0.67	0.47	0.71	0.36	0.65

Table 2 shows the average of the GL-index by country for the period 2010–2018. First, an index was calculated for each partner country, and then average values for each country were calculated. This gives a clearer picture of the values of intra-industry trade in EU countries.

The highest average values of the indexes are of Germany (0.68–0.70, Table 2).

Our next step was to search for linkages between the GL-index and the eco-innovations index. We used simple regression (ordinary least squares, OLS) because we aimed to obtain robust and easy understandable and replicable results.

Year by year regressions of the eco-index values on the average Grubel–Lloyd values (for each year we regress the GL index on the eco-index) have significant results for many of the years studied—there is a link between GL and the eco-index.

In the standard OLS models with an intercept, the *p*-values for the slope coefficients are significant at 5% in 2010, 2013, 2014, 2015, and 2018; for 2012, the coefficient is significant at 10% level with SITC one-digit and at 5% with SITC two-digit data. More specifically, the GL-index seems to be dependent on eco-innovation. In models without an intercept, *p*-values are very close to zero, indicating an even stronger interdependence. Our results confirm that for the bigger part of the years (2010–2018) R^2 values are greater than 0.16 and the variance explained of our particular endogenous construct is deemed adequate.

Table 2. Average GL-indexes, 2010–2018, EU-28. Source: Own calculations based on WITS data.

Year	AUT	BEL	BGR	CYP	CZE	DEU	DNK	ESP	EST	FIN	FRA	GBR	GRC	HRV
2010	0.65	0.58	0.51	0.34	0.62	0.69	0.59	0.59	0.45	0.52	0.64	0.59	0.45	0.48
2011	0.66	0.57	0.52	0.41	0.61	0.69	0.57	0.59	0.45	0.54	0.64	0.60	0.48	0.48
2012	0.64	0.58	0.52	0.36	0.62	0.69	0.60	0.60	0.43	0.54	0.64	0.58	0.45	0.48
2013	0.64	0.58	0.54	0.35	0.63	0.69	0.59	0.61	0.45	0.55	0.65	0.59	0.47	0.47
2014	0.64	0.59	0.54	0.36	0.64	0.69	0.61	0.63	0.42	0.56	0.66	0.59	0.46	0.48
2015	0.63	0.57	0.56	0.35	0.61	0.68	0.59	0.63	0.46	0.57	0.66	0.57	0.46	0.51
2016	0.65	0.59	0.60	0.36	0.64	0.70	0.59	0.65	0.48	0.58	0.67	0.61	0.48	0.53
2017	0.67	0.61	0.61	0.32	0.67	0.70	0.60	0.67	0.52	0.60	0.67	0.61	0.51	0.56
2018	0.69	0.61	0.63	0.35	0.66	0.72	0.63	0.67	0.52	0.60	0.70	0.60	0.49	0.54
	HUN	IRL	ITA	LTU	LUX	LVA	MLT	NLD	POL	PRT	ROM	SVK	SVN	SWE
2010	0.57	0.37	0.63	0.46	0.41	0.42	0.43	0.56	0.63	0.51	0.58	0.55	0.55	0.60
2011	0.59	0.37	0.64	0.44	0.42	0.42	0.35	0.57	0.64	0.53	0.60	0.58	0.57	0.58
2012	0.60	0.39	0.63	0.47	0.39	0.41	0.40	0.58	0.64	0.54	0.56	0.57	0.57	0.60
2013	0.59	0.43	0.62	0.52	0.41	0.42	0.39	0.59	0.64	0.55	0.58	0.57	0.58	0.62
2014	0.62	0.46	0.63	0.52	0.42	0.39	0.33	0.58	0.65	0.57	0.58	0.58	0.60	0.61
2015	0.59	0.44	0.64	0.53	0.42	0.43	0.34	0.59	0.65	0.57	0.62	0.56	0.59	0.61
2016	0.62	0.48	0.65	0.55	0.45	0.44	0.37	0.61	0.66	0.57	0.61	0.58	0.61	0.61
2017	0.65	0.47	0.67	0.55	0.46	0.48	0.40	0.60	0.67	0.58	0.63	0.60	0.63	0.66
2018	0.66	0.48	0.67	0.61	0.47	0.48	0.39	0.62	0.67	0.58	0.64	0.64	0.62	0.64

p-values of the slope coefficient are represented in the following Table 3.

Table 3. OLS results—*p*-values of slope coefficients, 2010–2018, EU-28. Source: Own calculations based on WITS data.

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018
SITC one-digit	0.035	0.246	0.079	0.033	0.026	0.026	0.181	0.107	0.01
SITC two-digit	0.0125	0.11	0.041	0.019	0.0225	0.0226	0.159	0.114	0.0462

We also calculated the standard deviation (coefficient of variation) of both the GL-indexes and the eco-innovation indexes, in order to explore whether there is a positive link between variances. The average standard deviation for the period, by country, regressed on the standard deviation of the eco-innovation index leads to significant results (F-statistic: 5.46 on 1 and 25 DF, *p*-value: 0.027), *p*-value for the slope coefficient is 0.027 (t = 2.306). We can claim the existence of a link between both variances, of the GL-index and of the eco-innovation index. Regressing the standard deviation of the eco-innovation index on the average values of the GL-index gives an even more interesting result—a *p*-value of 0.033 (Figure 3).

We argue that the level of the eco-innovation index is closely related to the level of intra-industry trade index. The use of the SITC Rev 1 two-digit level data (more disaggregated data for 60 sectors) only further supports our results, because p-values in the OLS regressions become smaller. In this case, the distinction between the polluting and non-polluting sector does not have a leading role, because it is country-specific and period-specific for each country and not a subject of cross-country analysis. Therefore, the measure for IIT (the GL-index) can be used as a proxy for eco-innovation level. The data for IIT have better availability, thus using this proxy makes sense.

5. Discussion

For a long time, the focus on innovations was concentrated on their dynamics in general. Among the large-scale efforts to measure innovation are: the European innovation scoreboard; OECD science technology and industry outlook; UNCTAD world investment report; OECD comparative innovation performance: countries and policies review; Eurostat CIS-2; etc. Specifically for the EU effort, the eco-innovation scoreboard, the calculations made are subject to large fluctuations by country, resulting in variations in the results obtained and might be misleading for the correct level of eco-innovation performance in a particular country. Measuring innovations is reasonable mainly for sustainability purposes, because many normal innovations are de facto eco-innovations. Our study confirms the need for prominent empirical tool to measure eco-innovation. Moreover, the degree of technological development of the countries depends on the degree of their trade exchange. For this reason, an alternative indicator is needed to act as a verifier of the eco-innovation index in order to ensure that this index is a suitable measure. One of the explanations for this fact is that the existing data for the eco-innovation index have been available since 2010 (less than 10 observations per country, because it is an annual index, with data for 2010–2018), therefore unit root and co-integration techniques just do not work, even the panel ones—with such data length tests have virtually no power at all. Therefore, we have adopted the strategy to make several OLS regressions for each year in the N dimension (we have ca. 30 countries). To exclude the possible endogeneity, we make the OLS in the "space" dimension—among countries, for the same year. For this reason, the OLS cannot be considered a basic one, but it is the only applicable in our study (considering the observations in the T dimension). Therefore, we offer a GL index, exploring carefully the empirical work guided by theory. Our research of EU countries for the period 2010–2018 shows that, due to the interrelation between eco-innovation and intra-industry trade (IIT), the GL index is a proxy indicator for eco-innovation performance across countries. The results of our research show that the GL-index and the eco-index reveal the strengths and weaknesses of each country in terms of eco-innovation and IIT in a similar way. We note that the intra-industry trade, and the simultaneous import and export of similar types of goods or services, determines the level of eco-innovations in all EU countries. The results of the study allow us to also place particular attention to the eco-innovation level by country. It is confirmed that the EU-28 countries are technologically different and the Eastern European countries have a lower degree of environmental progress. Our study confirms some other research results for the European countries: countries with a lower level of socio-economic activity as compared to their supportive environment need to prioritise on using more direct measures such as appropriate technology transfer to promote and increase the eco-innovation activities [30]. Our analysis also argues that the higher is the income in a given country, the higher are the levels of ecological development and IIT. In this context, the eco-innovation is becoming a problematic indicator for lower-income countries because the rising incomes affect environmental quality in a positive way. Our study amplifies the knowledge on some other observations [45] that IIT is linked to FDI inflows, particularly in Eastern European "transition" economies, because the low level of the eco-innovation index in these economies is also due to weak foreign investments in sustainable production and technology. The proposal for a proxy indicator fully corresponds to the eco-innovation mission to realise a new policy learning in Europe, as suggested by Kemp in 2011 [46] and better identification of policy mix and their instruments for sustainable development as mentioned in the platform of the European Sustainable Development Network [47]. Within the EU-28, this indicator can be implemented by the national governments as opportunity measure for successful trade and technological experience.

6. Conclusions

In this paper, we argue that trade policy should be assessed in light of the impact on sustainability and sustainable development strategies. The empirical evidence shows that the GL index is more intense among countries with high eco-innovation index, unlike those with a lower eco-index. This result is very important because there is a link between eco-innovations and trade, as demonstrated by Roy in 2017 [6]. For this reason, the adoption of measures aiming at improving the transition to eco-innovation (such as diffusion of green technologies or environmental certification) will improve the intra-industry trade favouring the whole economic performance. Constantini et al. (2017) [48] found that eco-innovations seem to be able not only to directly reduce pollution, but also to foster overall environmental performance via market transactions, both domestically and internationally. In our article, the Grubel–Lloyd Index does not show whether the eco-innovation is an effective way of favouring the transition to a low-carbon sustainable economy, or whether it relates to the degree of environmental pollution or environmental damage differences among sectors (as shown in other recent studies), but it illustrates that eco-innovation can be a driver to incentivise the intra-industry trade without compromising on the increasing greenhouse gas emissions, climate change, land degradation or energy consumption which characterise trade growth. To summarise, the Grubel–Lloyd Index is a proxy indicator of the eco-index. In the centre of our views, is the fact that it is the spread of environmental technologies what matters, and it happens in all sectors, thus a division in polluting/non-polluting sectors does not contribute much to the development of our ideas. Moreover, a rigorous sector-by-sector analysis seems for now not to be a feasible task, because of the scarcity of data; even for the EU data exist only for a limited number of countries (see [49]). Therefore, even an indirect measure, such as the one we propose, has the potential to be useful.

These results are strategic for helping to disseminate eco-innovations, and green knowledge among countries. Therefore, identifying clearly specific needs and barriers is a fundamental precondition to fostering the development and transfer of eco friendly technologies [50]. Environmental issues have been discussed in the scope of international trade in general—trade can lead to growth, and therefore to greater environmental awareness [51]. This study shows that the eco-innovation contributes to sustainability as a direct measure, but at the same time it is an incomplete indicator. A trend to investigate "eco-innovation–IIT interrelation" is emerging, because the existing indicators for measuring international trade can no longer be just a neutral mechanism for confirming or rejecting the sustainable welfare. IIT enhances sustainability, but IIT differs for goods and diffusion of innovations due to higher varieties in different countries. Our study helps to enrich the limited volume of empirical studies similar to the present and creates opportunities for new research.

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The Impact of Financial Development on Carbon Emissions: A Global Perspective

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Abstract: Financial development has been deemed to be an important factor influencing carbon emissions; however, the specific effect generated by financial development is still disputed. In this study, we examined the relationship between financial development and carbon emissions based on a system generalized method of moments and the data of 155 countries, and we further analyzed the national differences by dividing the sample countries into two sub-groups: developed countries, and emerging market and developing countries. The empirical results indicated that from a global perspective, financial development could significantly increase carbon emissions, and the analysis of the emerging market and developing countries reached the same conclusion; however, the results indicated that for developed countries, the effect of financial development on carbon emissions is insignificant. A series of robustness checks were conducted and confirmed that our empirical results were reliable. We suggest that policymakers in emerging market and developing countries should carefully balance financial development and environmental protection, as financial development will promote carbon emissions before countries reach a relatively high development level.

Keywords: financial development; carbon emission; global perspective; system GMM

1. Introduction

The issue of global warming has attracted worldwide attention. It is widely thought that this problem is caused by the excessive emission of greenhouse gases (GHGs), especially carbon dioxide. Many scholars have investigated the relationship between economic growth and carbon emissions, and have tried to determine how to mitigate this circumstance. The most well-known perspective is the environmental Kuznets curve (EKC) hypothesis proposed by Grossman and Krueger [1], which considers an inverted U-shaped relationship between the level of economic development and environmental quality. Many studies have validated the EKC hypothesis [2–4]; however, some scholars have proposed doubts or opposite opinions [5–7].

Many scholars have concentrated on the factors influencing carbon emissions, such as trade openness, urbanization, and population growth. In recent years, scholars have proposed that financial development is another important factor that could significantly affect carbon emissions, and the omission of a financial factor may lead to erroneous empirical results [8,9]. Therefore, scholars have conducted a series of studies on the influence of financial development on carbon emissions with different methodologies, indexes, and samples. The relevant research has not yet reached a consistent conclusion.

In this study, we analyzed the relationship between financial development and carbon emissions from a global perspective, on which scholars have rarely focused. We further divided the sample countries into two groups: developed countries, and emerging market and developing countries, which allowed us to detect the national differences in a unified framework.

The rest of this paper is arranged as follows: Section 2 provides a literature review, Section 3 describes the empirical strategy and sample data, Section 4 provides the empirical results and discussion, Section 5 outlines the robustness checks, Section 6 discusses the empirical results, limitations and further research direction, and Section 7 provides the conclusion and policy implications.

2. Literature Review

2.1. Theoretical Perspective

From the theoretical perspective of the influence of financial development on carbon emissions, scholars have proposed contradictory viewpoints. Some scholars [8,10,11] report that financial development could help reduce carbon emissions because of the following aspects: (1) in order to reduce production costs and enhance the market competitiveness of products, enterprises need to periodically update production technology and equipment which rely on adequate financial support. A developed financial system could facilitate enterprises to complete these works by effectively mitigating their financing constraints, which further indirectly decrease energy costs and reduce carbon emissions; (2) for the purpose of coping with environment degradation, governments generally tend to launch various environmentally friendly projects, promote overall industrial transformation, and the use of clean energy. Based on the corresponding policy arrangement, the financial institutions could provide necessary funds for the operation of these projects or programs, which could help to improve the energy infrastructure and finally reduce carbon emissions; (3) the enterprises listed on the stock market are generally outstanding enterprises which have significant influence on national economy. Due to the requirement of the stock exchange, they need to undertake regular information disclosure and are subject to strict supervision of the financial authorities and the public. This enforces them to establish a good image, such as assuming the social responsibility of environmental protection by utilizing environmentally friendly technologies, which could reduce carbon emissions. These can be called the "negative effects" of financial development on carbon emissions.

Other scholars [12–14] consider that financial development increases carbon emissions due to the following reasons: (1) a well functioned financial system could effectively relieve the problem of information asymmetry, expand financing channels, to enable the enterprises to obtain lending capitals with much lower costs which facilitate their expansion of the production scale (such as building a new production line, renting more equipment, and employing more workers), and therefore significantly increase carbon emissions; (2) likewise, the development of the financial sector could provide more and better service of consumption credit, which facilitates their intertemporal consumption and encourages them to purchase more commodities such as properties, automobiles, and other electric appliances. These would dramatically promote the expansion of social consumption and further increase carbon emissions; (3) the stock market generally acts as an important barometer of economic conditions, good performance of the stock market often implies the rapid growth and prosperity of the economy, which in turn greatly enhances the confidence of enterprises and consumers and stimulates the activities of production and consumption, therefore leading to the increase of energy consumption and carbon emissions. These can be called the "positive effects" of financial development on carbon emissions.

2.2. Empirical Research

To provide empirical evidence for the nexus of financial development and carbon emissions, scholars have conducted abundant research with different models and samples; however, these studies still do not yet provide a consensus. Overall, there are three main viewpoints in the empirical research: financial development reduces carbon emissions, increases carbon emissions, and other perspectives.

2.2.1. Financial Development Reduces Carbon Emissions

Tamazian and Rao [15] study the relationship between financial development and environmental degradation with a system generalized method of moments (GMM) estimation and the panel data of 24 transition economies from 1993–2004. They conclude that in transitional economies, financial development plays a positive role in environmental disclosure and can help to reduce carbon emissions.

Saidi and Mbarek [16] investigate the influence of financial development on carbon emissions based on a system GMM model and the time series data of 19 emerging economies from 1990–2013. The empirical results indicate that financial development has had a long-term negative impact on carbon emissions, which indicates that environmental degradation could be minimized by financial development.

Based on the time series data from South Africa for 1965–2008, and using the autoregressive distributed lag (ARDL) bounds testing approach for the cointegration and error correction method, Shahbaz et al. [9] find that financial development can reduce carbon emissions, which implies that financial reforms can be introduced to help maintain or improve the environment.

Omri et al. [17] study the relationship between financial development and carbon emissions using the simultaneous-equation panel data model and the data of 12 Middle East and North Africa (MENA) countries for the period of 1990 to 2011. The results show that higher levels of financial system development could increase the input of energy conservation R&D, which can promote technological innovations and eventually lower carbon emissions.

Using dynamic ordinary least squares (DOLS) and fully modified ordinary least squares (FMOLS) methods, Dogan and Seker [18] research the long-run dynamic relationship of financial development and carbon emissions based on the panel data of 23 top renewable energy countries from 1985–2011; they find that the analyzed variables are cointegrated and financial development could reduce carbon emissions.

Zaidi et al. [19] examine the dynamic relationship of financial development and carbon emissions in the EKC framework with continuously updated bias-corrected (CUP-BC) and continuously updated fully modified (CUP-FM) methods and the panel data of 17 Asia Pacific Economic Cooperation (APEC) countries from 1990–2016. The empirical results indicate that the financial development could reduce carbon emissions both in the long-run and short-run. Similarly, Zafar et al. [20] find this conclusion is also valid for Organization for Economic Co-operation and Development (OECD) countries.

2.2.2. Financial Development Increases Carbon Emission

Al-Mulali et al. [21] investigate the relationship between financial development and carbon emission in 23 selected European countries with the panel-pooled FMOLS model and conclude that financial development could increase carbon emissions in the long-run.

Zhang [13] consider financial development as one of the main factors that increase carbon emissions in China using a series of empirical methods and a couple of proxy variables for financial development. The research also discovers that the financial intermediation scale had the most outstanding influence on carbon emissions compared with other indictors of financial development.

Shahbaz et al. [22] examine the asymmetric impact of financial development on carbon emission in Pakistan with quarterly data from Q1 1985 to Q4 2014, and a calculated comprehensive index of financial development based on bank and stock-market indicators. The results indicate that financial development in the banking sector could increase carbon emissions via positive shocks, and this appears to be a unidirectional causality.

Bekhet et al. [23] examine the relationship between financial development and carbon emissions in Gulf Cooperation Council (GCC) countries with the ARDL model, and the empirical results indicate that the unidirectional causality of financial development to carbon emissions exists in the United Arab Emirates (UAE), Oman, and Kuwait.

Lu [24] studies the causality relationship between financial development and carbon emissions based on a panel causality test and the panel data of 12 Asian countries from 1993–2013. The empirical result shows that financial development causes carbon emissions.

Cetin et al. [25] examine the influence of financial development on carbon emissions in Turkey based on an ARDL bounds testing approach and vector error correction model (VECM) Granger causality test and the annual time series data for the period of 1960–2013. They discover a positive relationship between financial development and carbon emissions in the long-run, and the causality test reveals the unidirectional causality running from financial development to carbon emissions. Similarly, Ali et al. [26] study the dynamic links between financial development and carbon emissions in Nigeria with the ARDL bound test approach and the data period of 1971–2010, and conclude that financial development has a positive and significant impact on carbon emissions in both the long-run and short-run.

2.2.3. Other Perspectives

Dogan and Turkekul [14] analyze the relationship between financial development and carbon emissions in the USA from 1960 to 2010 with the ARDL approach and error correction-based Granger causality test, and conclude that although the financial development could affect the output, it has no effect on carbon emissions in the long-term. Similarly, based on the panel vector autoregressive (PVAR) model and the data of 24 countries in the MENA region from 1980 to 2015, Charfeddine and Kahia [27] find that financial development only slightly influences carbon emissions.

Paramati et al. [28] investigate the relationship between stock markets and carbon emissions in 23 developed and 20 emerging market countries from 1992 to 2011 with the Durbin–Hausman test and the common correlated effects (CCE) approach, and find that the influence of the stock market on carbon emissions differs between developed countries and emerging market countries. More specifically, the stock market indicators significantly negatively affect carbon emissions in developed countries but positively affects emerging market countries.

2.3. Comment and Discussion

From the above literature review, we can discover that the influence of financial development on carbon emissions is still under debate in both the theoretical and empirical research, which reflect the complexity of their relationship which cannot be readily detected or described.

Specifically, the theoretical research reveals that the financial development has both positive and negative effects on carbon emissions, the aggregate effect might be determined by the relative size of these positive and negative effects. The empirical research reflects that the influence of financial development on carbon emissions varies across countries and regions. Actually, it also demonstrates the viewpoint of the theoretical research to some extent, as it is reasonable to consider both the positive and negative effects are divergent in different countries and regions. Although the influence of financial development on carbon emissions remains in dispute, the relevant research on this topic have provided important theoretical values for environmental policy making.

However, two limitations exist in the literature on this topic: firstly, most of the researchers selected regional or individual country samples as the research objects, but few focused on this issue from a global perspective; secondly, the application of different methods, samples, and data, has created challenges for comparing research completed by different scholars.

Considering the above limitations, we collected a comprehensive country sample that contained the data of 155 countries to analyze the influence of financial development on carbon emissions from the global perspective, in order to provide more empirical evidence on this topic.

3. Empirical Strategy and Data

3.1. Empirical Model and Methodology

In this paper, we focused on three research objectives: first of all, we analyzed the influence of financial development on carbon emissions from the global perspective based on panel data of 155 countries, which could enable us to detect their relationship on a macro angle; in addition, we researched this issue by dividing the sample countries into two sub-groups—developed countries, and emerging market and developing countries, to detect national differences under a unified analytical framework. The discrepancy of the empirical results reflects the heterogeneous effect of financial development on carbon emissions in different countries and regions. However, due to the inconsistent samples, proxy variables and methodologies adopted by scholars, it was quite difficult to compare their empirical results in a unified framework. Therefore, after the full sample analysis, we further divided our sample into different sub-groups to examine the national effect of financial development on carbon emissions across different types of countries, in the same empirical framework. According to general practice in the empirical works [29–31], we divided our sample countries into two sub-groups—developed countries, and emerging market and developing countries, as it is widely believed by the scholars that a significant discrepancy in the aspects of economic structure, technical level, and resource endowment exists between these two groups, which may result remarkable implications on macro factors (please refer to Appendix A for more information about the country classification); lastly, we investigated the influence of different aspects of financial development on carbon emissions by adopting a series proxy variables of financial development. Much research deems financial development as a unique concept and takes one or two indexes to be its proxy variables. Actually, scholars commonly believe that financial development has rich connotation that can be divided into different aspects, therefore, besides the use of a comprehensive index, we further adopted five concrete indexes of financial development to analyze the effect of different aspects of financial development on carbon emissions, apart from its aggregate effect, to provide more specific evidence on this topic.

Considering the above research objectives and following the general practice on this topic [15,21,28], we established the dynamic panel model below:

$$CE_{it} = \alpha + \beta_0 CE_{it-1} + \beta_1 FD_{it} + \gamma Control_{it} + \mu_i + \varepsilon_{it} \tag{1}$$

where CE_{it} represents carbon emission; FD_{it} signifies financial development; $Control_{it}$ denotes a series of control variables; β_0, β_1, and γ are the corresponding coefficients; μ_i represents the unobserved country specific effect; ε_{it} is the residual term; and i and t indicate the country and time, respectively.

We introduced the lag-term of carbon emissions into the regression equation to reflect the dynamic process of carbon emissions, which was consistent with reality. Adding a lag-term can eliminate the influence of uncontrollable factors, increasing the credibility of the regression results.

As a result of the existence of a lag-term, the model could not be estimated by ordinary least squares (OLS) or traditional panel model estimation methods (such as fixed-effect or random-effect), as they would have caused an endogenous problem and therefore could not provide effective estimators. To solve this problem, we adopted the generalized method of moments (GMM) [32–34] to estimate the above model. GMM can be divided into difference GMM and system GMM; each of them can further be divided into one-step and two-step estimation methods according to the selection of different weight matrixes.

Compared with the difference GMM, the system GMM can help mitigate the problems of weak tools and limited sample errors and can improve the efficiency of estimation. The two-step estimation performed better in handling the autocorrelation and heteroscedasticity problems than one-step estimation. Therefore, we adopted a two-step system GMM method to estimate our model. We adopted Stata (StataCorp, College Station, Texas, USA) and the command "xtabond2" to complete the estimations. Please refer to Roodman [35] for more details about this command. We conducted the test of serial correlation and the effectiveness of instrument variables to examine the consistency of the estimators, based on relevant statistics. In addition, the Hansen test was used to judge the effectiveness of the instrument variables rather than the Sargan test, as Roodman [35] shows that the Sargan test is not robust to heteroscedasticity or autocorrelation.

3.2. Data

So far, no indictors are widely accepted as proxy variables of financial development due to their rich and complex connotation. Scholars adopt many different indicators according to their research objectives and the data availability [36–40]. In our research, we used the comprehensive index of financial development proposed by Svirydzenka [41] in the main regression, which allowed us to investigate the "aggregate" effect of financial development on carbon emissions. Please refer to Appendix B for more information of this index.

To analyze the influence of different aspects of financial development on carbon emissions and to guarantee the reliability and accuracy of the empirical results, we also adopted another five variables as the proxies of financial development besides the comprehensive index proposed by Svirydzenka [41].

Following the common research on carbon emissions [27,42,43], we used carbon dioxide emissions (metric tons per capita) as its proxy, and selected four control variables: trade openness, urbanization, population growth, and industrial structure. The details of the variables used in our model are presented in Table 1.

Table 1. Variable descriptions.

Variables	Symbol	Measurable Indicator
Carbon emission	CE	carbon dioxide emissions (metric tons per capita)
Financial development 1	FD1	A comprehensive index proposed by Svirydzenka [41]
Financial development 2	FD2	Domestic credit to the private sector (% of GDP)
Financial development 3	FD3	Domestic credit provided by the financial sector (% of GDP)
Financial development 4	FD4	Domestic credit to the private sector by banks (% of GDP)
Financial development 5	FD5	Total value of traded stocks (% of GDP)
Financial development 6	FD6	Market capitalization of listed domestic companies (% of GDP)
Trade openness	TRADE	Total import and export (% of GDP)
Urbanization	URBAN	Urban population (% of total population)
Population growth	POP	Population growth (%)
Industrial structure	IND	Industrial value added (% of GDP)

Note: GDP denotes gross domestic product.

According to the data availability, our sample contained 155 countries, including 35 developed countries and 120 emerging market and developing countries. The main regression data cover the period from 1990 to 2014, and in the robustness checks, the period was extended to 1960–2014. All the variables were extracted from the World Development Indicators database of the World Bank, except for the financial development (FD)1 variable, which was sourced from the International Monetary Fund (IMF) database. All the variables were transformed into the natural logarithms to reduce nonnormality and heteroscedasticity [44], except for FD1 and population growth (POP) as they were already dimensionless or ratio indexes. Table 2 displays the descriptive statistics of the variables for the main regression. We adopted several regressions in the section of empirical analysis, and to save space, the descriptive statistics of the other regressions are not presented but are available from the authors upon request.

Table 2. Descriptive statistics of main regression.

Variable	Obs.	Mean	SD	Min	Max
CE	3875	4.401446	5.217805	0.0107325	35.67826
FD1	3875	0.2996452	0.2147667	0.0001266	1
TRADE	3875	84.90056	51.85297	0.1674176	442.62
URBAN	3875	54.68968	22.93943	5.416	100
POP	3875	1.469806	1.403123	−9.080639	14.23679
IND	3875	27.02753	11.72264	2.525526	87.79689

Note: Obs. denotes number of observations. SD denotes standard deviation.

Table 3 presents the correlation matrix of all the variables in the main regression. Generally, when all the correlation coefficients of each of the variables are less than 0.85, the model is considered to not have a multicollinearity problem [45,46]. Table 3 shows that all the correlation coefficients were less than 0.85; therefore, we thought that our model was not affected by the multicollinearity problem. We also calculated the correlation matrixes for other regressions besides the main regression; all of the correlation coefficients were less than 0.85.

Table 3. Correlation matrix of the variables.

Variable	CE	FD	TRADE	URBAN	POP	IND
CE	1.0000					
FD1	0.5765	1.0000				
TRADE	0.2780	0.2535	1.0000			
URBAN	0.5913	0.6162	0.2600	1.0000		
POP	−0.0875	−0.2779	−0.0557	−0.2083	1.0000	
IND	0.2889	0.0028	0.0239	0.2666	0.0687	1.0000

4. Results and Comments

4.1. Unit Root Test and Co-Integration Test

In the panel models, non-stationary sequences data cause the problem of spurious regression, which further leads to errors in estimating the results. To avoid this circumstance, we adopted five commonly-used unit root tests [47–51] to examine the stationarity of the data. Note, to save space, we only report the results of the unit-root test and co-integration test for the main regression (full sample); all the other regressions also passed these two tests, and the results are available from the authors upon request. Table 4 displays the results of the unit root test. All the variables were stationary sequences. However, as some of the variables were not significant in certain unit root tests, we examined the stationarity of the first-order difference of the variables, and the results indicated that all the unit root tests were significant at the 1% level, which implied that all the variables were at least integrated at an order of one. We further investigated the co-integration relationship among the panel data series using three co-integration tests [52–54]. The results in Table 5 show that the null hypotheses of "no co-integration" were rejected by all three tests, which implied that the co-integration relationship did exist; therefore, we continued our research by establishing the panel data model.

Table 4. Panel unit root test.

Variable	LLC	IPS	HT	Breitung	Fisher	Result
CE	−9.7494 *** (0.0000)	−2.6540 *** (0.0040)	0.7965 *** (0.0000)	−4.4546 *** (0.0000)	−14.4344 *** (0.0000)	Stationary
FD1	−2.0384 ** (0.0208)	−7.1101 *** (0.0000)	0.6864 *** (0.0054)	−0.9862 (0.1620)	−20.1141 *** (0.0000)	Stationary
TRADE	−2.0984 ** (0.0179)	−8.7928 *** (0.0000)	0.9668 *** (0.0000)	−0.3006 (0.3819)	−18.4495 *** (0.0000)	Stationary
URBAN	−7.5215 *** (0.0000)	−4.2556 *** (0.0000)	0.9911 ** (0.0277)	−2.5344 *** (0.0056)	−12.2500 *** (0.0000)	Stationary
POP	−3.5694 *** (0.0002)	−13.4064 *** (0.0000)	0.6788 *** (0.0010)	−5.8143 *** (0.0000)	−21.4217 *** (0.0000)	Stationary
IND	−1.1602 (0.1230)	−5.8703 *** (0.0000)	0.9803 *** (0.0000)	−4.9941 *** (0.0000)	−18.2061 *** (0.0000)	Stationary
D.CE	−28.9265 *** (0.0000)	−46.1653 *** (0.0000)	−0.0992 *** (0.0000)	−3.3300 *** (0.0004)	−25.4232 *** (0.0000)	Stationary
D.FD1	−14.3504 *** (0.0000)	−46.3067 *** (0.0000)	−0.0513 *** (0.0000)	−20.3993 *** (0.0000)	−27.1963 *** (0.0000)	Stationary

Table 4. *Cont.*

Variable	LLC	IPS	HT	Breitung	Fisher	Result
D.TRADE	−35.4105 *** (0.0000)	−40.3827 *** (0.0000)	−0.0499 *** (0.0000)	−5.9384 *** (0.0000)	−28.3424 *** (0.0000)	Stationary
D.URBAN	−11.2854 *** (0.0000)	−7.3126 *** (0.0000)	0.8334 *** (0.0000)	−7.2693 *** (0.0000)	−17.5905 *** (0.0000)	Stationary
D.POP	−25.2584 *** (0.0000)	−28.1894 *** (0.0000)	−0.1676 *** (0.0000)	−5.4290 *** (0.0000)	−29.6550 *** (0.0000)	Stationary
D.IND	−35.4769 *** (0.0000)	−40.1566 *** (0.0000)	−0.0186 *** (0.0000)	−8.0727 *** (0.0000)	−26.1916 *** (0.0000)	Stationary

Notes: CE denotes carbon emission. FD1 denotes financial development 1. TRADE denotes trade openness. URBAN denotes urbanization. POP denotes population growth. IND denotes industrial structure. D. denotes the first-order difference of each variable. LLC denotes Levin-Lin-Chu test. IPS denotes Im–Pesaran–Shin test. HT denotes Harris–Tzavalis test. The values in parentheses are the *p*-values. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

Table 5. Co-integration test.

Method	Statistics
Kao	−3.6924 *** (0.0001)
Pedroni	15.0573 *** (0.0000)
Wester Lund	−3.1521 *** (0.0008)

Notes: Values in parentheses are the *p*-values. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

4.2. Result of Full Sample Regression

Table 6 presents the full sample of the empirical results of the effect of financial development on carbon emissions with stepwise regressions. For all the regressions, the first-order serial correlation tests were significant at the 1% level, and the second-order serial correlation tests and Hansen tests were not significant. These misspecification tests proved the appropriateness of the GMM specification. The results of the regression showed that financial development had a positive effect on carbon emissions, as the coefficients were positive and significant at the 1% level. This implied that financial development could increase carbon emissions from a global perspective. The stepwise regressions indicated that our main conclusion was not affected by the change in the control variables.

Table 6. Results of the full sample regression.

Variable	Full Sample				
L.CE	0.8590315 *** (0.0273400)	0.8564305 *** (0.0277124)	0.7609177 *** (0.0499821)	0.7791862 *** (0.0512527)	0.7701393 *** (0.0535405)
FD1	0.6984505 *** (0.1477555)	0.6733399 *** (0.1434213)	0.6195633 *** (0.1505502)	0.5359521 *** (0.1379598)	0.6058228 *** (0.1408755)
TRADE	-	0.0748495 *** (0.0241799)	0.0866933 *** (0.0320083)	0.0793764 *** (0.0280387)	0.0777544 ** (0.0316622)
URBAN	-	-	0.4064496 *** (0.0934621)	0.3622845 *** (0.0877871)	0.3300433 *** (0.0845282)

Table 6. *Cont.*

Variable	Full Sample				
POP	-	-	-	−0.0343910 ** (0.0172426)	−0.0367518 ** (0.0167301)
IND	-	-	-	-	0.1540209 *** (0.0475216)
Constant	−0.1224928 *** (0.0367231)	−0.4343379 *** (0.1237564)	−1.9999469 *** (0.4426030)	−1.7304080 *** (0.4008894)	−2.1036362 *** (0.5139327)
Number of countries	155	155	155	155	155
AR (1)	−6.03 *** (0.000)	−6.04 *** (0.000)	−5.76 *** (0.000)	−5.79 *** (0.000)	−5.80 *** (0.000)
AR (2)	−0.21 (0.831)	−0.33 (0.743)	−0.40 (0.691)	−0.27 (0.786)	−0.01 (0.992)
Hansen test	149.62 (0.140)	150.74 (0.126)	147.61 (0.167)	146.89 (0.178)	145.29 (0.203)

Note: L. denotes the first-order lag term of variables. AR (1) denotes the first-order autocorrelation estimator. AR (2) denotes the second-order autocorrelation estimator. Values in parentheses are standard errors. For AR (1), AR (2), and the Hansen test, the values in parentheses are the *p*-values. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively. These notes are the same for the following tables.

According to the theoretical analysis, the influence of financial development on carbon emissions is uncertain. Some scholars [8,10,11] consider that financial development could fund the innovative activities of enterprises and environmentally friendly projects, which improve productivity and decrease the use of energy, thereby reducing carbon emissions. This can be called the "negative effect" of financial development on carbon emissions. However, other scholars [12–14] report that the development of the financial sector could stimulate the demand for energy consumption and the expansion of production scale, which increase carbon emissions. This can be called the "positive effect" of financial development on carbon emissions. Overall, the total impact is determined by the relative size of the negative and positive effects [18,55]. The empirical results indicated that the positive effect exceeds the negative effect in our sample and occupied the dominant position. Therefore, this result showed that on a worldwide level, the effect of financial development was more a promotion than reduction of carbon emissions. This conclusion is consistent with the work of Al-Mulali et al. [21], Bekhet et al. [23], and Lu [24].

4.3. Results of Sub-Sample Regressions

The above empirical analysis proved that from a global perspective, financial development has a positive effect on carbon emissions. However, this conclusion may not be valid for countries in different stages of development, as these countries have an obvious discrepancy in economic structure, technical level, and resource endowment. Therefore, we further analyzed the relationship between financial development and carbon emissions by dividing the sample countries into the following two groups: developed countries, and emerging market and developing countries. Table 7 presents the regression results.

Table 7. Results of the sub-sample regressions.

Variable	Developed Countries	Emerging Market and Developing Countries
L.CE	0.9560886 *** (0.0864221)	0.7292117 *** (0.0591621)
FD1	0.0251260 (0.0533522)	1.2738184 *** (0.2792448)
TRADE	−0.0036297 (0.0110794)	0.1034371 ** (0.0503334)
URBAN	0.0181402 (0.0320493)	0.3817556 *** (0.0855947)
POP	0.0060512 (0.0091576)	−0.0398173 ** (0.0182942)
IND	0.0334594 (0.0432423)	0.1275443 *** (0.0491280)
Constant	−0.1030257 (0.1206784)	−2.4493158 *** (0.5447357)
Number of countries	35	120
AR (1)	−3.12 *** (0.002)	−5.26 *** (0.000)
AR (2)	−0.29 (0.773)	−0.02 (0.986)
Hansen test	30.51 (0.135)	113.98 (0.430)

Note: ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

According to the empirical results, the coefficient of financial development was positive for developed countries, but insignificant both in terms of statistics and economics. However, the coefficient of financial development was positive and significant at the 1% level for emerging market and developing countries, which was similar to the full sample regression. This indicated that the financial development has positive effect on carbon emissions in emerging market and developing countries, and had no obvious effect in developed countries.

This result may be explained by developed countries generally having well-developed industrial systems and strict environmental regulations. Therefore, enterprises tend to invest in technological innovation but not scale expansion, and the government prefers to support the development of green finance, which leads to more funding in environmental protection projects. Although the development of the financial sector also stimulates consumption, which can generate more emissions, these positive and negative effects tend to neutralize and eliminate the negative influence of financial development on carbon emissions.

Conversely, emerging market and developing countries often face tremendous pressure to develop economically, and the first priority is to increase output rather than environmental protection. The enterprises tend to expand production scale though credit rather than developing energy saving technology; therefore, the development of the financial sector could indirectly increase carbon emissions. The mitigation of financing the constraints of the consumers could also increase consumption and eventually enhance the positive effect of financial development.

These empirical results are similar with the works of Shahbaz et al. [22], Dogan and Turkekul [14] and Paramati et al. [28], which reflect the national difference of the effect of financial development on carbon emissions.

4.4. Results of Regressions with Different Proxy Variables of Financial Development

The previous section analyzed the "aggregate" effect of financial development on carbon emissions with a comprehensive index proposed by Svirydzenka [41]. However, scholars commonly consider that financial development has rich connotation and can be further divided into different aspects, and the macro effect of financial development may vary if we focus on its different aspects. Therefore, in this section, we investigated the influence of different aspects of financial development on carbon emissions with a series of proxy variables of financial development, to detect the relationship of financial development and carbon emissions for a comprehensive angle, and to verify the reliability and accuracy of the previous empirical results.

The proxy variables of financial development used in this section were FD2–FD6. Generally, financial development is divided into the development of financial institution and the development of stock market (corresponding with indirect financing and direct financing respectively). We used FD2, FD3 and FD4 as the proxy variables of the development of financial institution, and FD5 and FD6 to be the proxy variables of the development of stock market. As the FD2, FD3, and FD4 indexes had a relatively adequate sample size, we not only estimated the full sample regression but also the sub-sample regressions when we used these three proxies. However, given the limited data availability, we only estimated the full sample regression when we used the FD5 and FD6 indexes. Tables 8–11 present the results of the regressions.

Table 8. Results of the full sample and sub-sample regressions (explanatory variables: financial development variable two, FD2).

Variable	Full Sample	Developed Countries	Emerging Market and Developing Countries
L.CE	0.7158688 *** (0.0535541)	0.8430449 *** (0.1012896)	0.6349239 *** (0.0691121)
FD2	0.1589478 *** (0.0297083)	0.0106708 (0.0200120)	0.2067815 *** (0.0403396)
TRADE	0.0610658 * (0.0343227)	−0.0020720 (0.0262351)	0.0903411 (0.0567861)
URBAN	0.4440801 *** (0.0952552)	0.0694749 (0.0512456)	0.5618609 *** (0.1139001)
POP	−0.0434512 ** (0.0193565)	0.0092695 (0.0142356)	−0.0555434 ** (0.0264847)
IND	0.1977202 *** (0.0497561)	0.0905716 (0.0730781)	0.2278650 *** (0.0742844)
Constant	−2.9381255 *** (0.5697875)	−0.3130130 (0.2920472)	−3.7340408 *** (0.7032304)
No. countries	155	35	120
AR (1)	−5.89 *** (0.000)	−3.11 *** (0.002)	−5.07 *** (0.000)
AR (2)	−0.07 (0.948)	−0.29 (0.773)	0.02 (0.982)
Hansen test	144.81 (0.210)	30.40 (0.138)	104.01 (0.166)

Note: ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

Table 9. Results of the full sample and sub-sample regressions (explanatory variables: FD3).

Variable	Full Sample	Developed Countries	Emerging Market and Developing Countries
L.CE	0.7317546 *** (0.0543573)	0.8479038 *** (0.0896954)	0.6552704 *** (0.0684584)
FD3	0.1519494 *** (0.0306952)	−0.0474410 (0.0463207)	0.1874231 *** (0.0390445)
TRADE	0.0893570 *** (0.0325994)	0.0655369 (0.0763839)	0.1328738 ** (0.0541487)
URBAN	0.4296097 *** (0.0968563)	0.0700011 (0.1447222)	0.5160384 *** (0.1129521)
POP	−0.0321672 * (0.0176906)	−0.0128571 (0.0190466)	−0.0457082 * (0.0250292)
IND	0.1799730 *** (0.0529909)	0.1900178 (0.1325729)	0.2345657 *** (0.0752635)
Constant	−2.9999570 *** (0.6089951)	−0.6338886 (1.1928016)	−3.7893095 *** (0.7315792)
No. countries	147	28	119
AR (1)	−5.64 *** (0.000)	−2.45 ** (0.014)	−5.12 *** (0.000)
AR (2)	−1.01 (0.311)	−1.12 (0.262)	−0.83 (0.406)
Hansen test	142.65 (0.248)	25.45 (0.185)	101.37 (0.215)

Note: ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

Table 10. Results of the full sample and sub-sample regressions (explanatory variables: FD4).

Variable	Full Sample	Developed Countries	Emerging Market and Developing Countries
L.CE	0.6721688 *** (0.0631201)	0.7831462 *** (0.0913885)	0.6289033 *** (0.0703863)
FD4	0.1702764 *** (0.0340425)	0.0089098 (0.0557672)	0.1872831 *** (0.0375433)
TRADE	0.0677760 * (0.0360426)	0.0217901 (0.0933853)	0.1009734 * (0.0562001)
URBAN	0.5187499 *** (0.1166181)	0.1714139 (0.1330308)	0.5778977 *** (0.1218666)
POP	−0.0437665 * (0.0226795)	0.0000919 (0.0176074)	−0.0518710 ** (0.0262629)
IND	0.1997536 *** (0.0556928)	0.2439661 ** (0.1035543)	0.2122822 *** (0.0819533)
Constant	−3.2648075 *** (0.6613276)	−1.1937344 (0.9307830)	−3.7016372 *** (0.7736308)

Table 10. *Cont.*

Variable	Full Sample	Developed Countries	Emerging Market and Developing Countries
No. countries	139	29	110
AR (1)	−5.19 *** (0.000)	−2.64 *** (0.008)	−4.75 *** (0.000)
AR (2)	−0.39 (0.696)	−0.51 (0.612)	−0.33 (0.744)
Hansen test	127.65 (0.148)	25.50 (0.183)	96.72 (0.321)

Note: ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

Table 11. Results of the full sample regressions (explanatory variables: FD5 and FD6).

Variable	FD5	FD6
L.CE	0.4636904 *** (0.1447732)	0.6942905 *** (0.0726658)
FD5/FD6	0.0492784 *** (0.0173954)	0.0785047 *** (0.0258335)
TRADE	0.1550326 ** (0.0677723)	0.0916717 * (0.0529239)
URBAN	0.9723596 *** (0.3228306)	0.2732316 (0.2332033)
POP	−0.0794701 ** (0.0383007)	−0.0627705 ** (0.0297382)
IND	0.20759 (0.1451585)	0.2250498 ** (0.1007877)
Constant	−4.621357 *** (1.396115)	−2.033003 ** (0.9811004)
Number of countries	60	48
AR (1)	−2.47 ** (0.013)	−3.50 *** (0.000)
AR (2)	−1.02 (0.306)	−1.07 (0.285)
Hansen test	53.25 (0.114)	43.92 (0.271)

Note: ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

Tables 8–10 show that the coefficients of FD2, FD3, and FD4 for the full sample regressions were 0.1589478, 0.1519494, and 0.1702764, respectively, and were significant at the 1% level. For the sub-sample regressions in Tables 8–10, the coefficients of developed countries were all small and insignificant, and the coefficients of emerging market and developing countries were all positive and significant at the 1% level. In addition, Table 11 shows that the coefficients of FD5 and FD6 were 0.0492784 and 0.0785047, respectively, which were significant at the 1% level.

By comparing the values of coefficients of FD2–6, we can readily notice that for FD2–4 and FD5–6 respectively, they were quite close with each other while the coefficients of FD2–4 were evidently larger than FD5–6, which implied that the development of financial institution had greater influence on carbon emissions than the development of the stock market (it was reasonable to believe this conclusion was reliable as we adopted more than one proxy variables for each aspect). This may have been caused by the following reasons: the stock market allows listed companies to access an additional source of equity financing besides the debt financing, which leads to the consumption of more energy by stimulating the growth of business, and finally contributes to the increase of carbon emissions, however, the listed companies are strictly supervised by the financial authorities and the public, therefore they will emphasize the social responsibility of environmental protection and utilize more advanced technologies which could increase the energy efficiency and reduce carbon emissions. To the contrary, the companies acquire their loans mainly from financial institutions not subject to these limitations and consequently have less motivation on environmental protection during their productive activities. Therefore, the coefficients of FD5–6 which represent the development of the stock market, were relatively smaller compared with FD2–4 which represent the development of financial institution.

In addition, these empirical results also have the following implications: (1) while we divided the financial development into two aspects by adopting other five proxy variables, all of their coefficients were significantly positive, which were inconsistent with the result of regression using the index of FD1, this further proved that the financial development could significantly increase carbon emissions from the global perspective; (2) the results of sub-sample regressions in Tables 8–10 indicated that the financial development has no obvious effect on carbon emissions while it has a positive effect on carbon emissions in the emerging market and developing countries, which further proved the conclusion of the sub-sample regressions with FD1.

5. Robustness Checks

The previous empirical analysis proved that financial development can increase carbon emissions from a global perspective, in this section, we conducted two robustness checks to verify the reliability of the above empirical results.

5.1. Different Estimation Methods

We chose the system GMM to estimate the models because it could effectively cope with the endogenous problems of a dynamic panel. In this section, we adopted a static panel and the traditional estimation strategies, which include the pooled OLS, fixed effect (FE), and random effect (RE) to examine the influence of financial development on carbon emissions and the robustness of our empirical results.

Table 12 presents the estimation results of the static panel model. All the coefficients of FD1 were significant at the 1% level, which was consistent with the previous results. The Hausman test indicated that the fixed effect was better than the random effect model; however, we reported both of the results, which were quite similar. These empirical results proved that our conclusions were consistent under different model specifications, and further indicated that our model might not seriously suffer from the issue of endogeneity, as we could notice the value of coefficients estimated by the fixed effect, random effect and GMM were quite similar. As we know, the issue of endogeneity is generally caused by the existence of reverse causality, however the above analysis indicated that the reverse causality might not exist in the relationship of financial development and carbon emissions. This is consistent with most works of scholars, as very little research has reported the appearance of reverse causality on it.

Table 12. Results of the static panel regressions.

Variable	Pooled OLS	Fixed Effect	Random Effect
FD1	2.6474191 *** (0.0760941)	0.4073476 *** (0.0635407)	0.5058472 *** (0.0638911)
TRADE	0.3645025 *** (0.0209273)	0.0092904 (0.0168561)	0.0044025 (0.0169482)
URBAN	1.4861864 *** (0.0338968)	1.2674027 *** (0.0448558)	1.3752265 *** (0.0434128)

Table 12. *Cont.*

Variable	Pooled OLS	Fixed Effect	Random Effect
POP	−0.2018761 *** (0.0097875)	−0.0214406 *** (0.0051369)	−0.0258266 *** (0.0052231)
IND	0.6594443 *** (0.0333297)	0.2317015 *** (0.0217389)	0.2462267 *** (0.0220302)
Constant	−9.4038995 *** (0.1475040)	−5.2551822 *** (0.1774299)	−5.7234972 *** (0.1832383)
No. countries	155	155	155

Note: ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

5.2. Longer Sample Periods

When we adopted the panel data analysis, we often had to balance the number and the period of the sample data, as they generally appeared to have a negative correlation. In our main regression, we chose the panel data of 155 countries from 1990 to 2014, as we thought that this would be the best sample size for our analysis according to the data characteristics. We attempted to analyze the relationship between financial development and carbon emissions from the perspective of a longer time dimension by extending the sample period. This lost more sample countries but allowed us to examine whether the above conclusions were valid in the long-term.

Specifically, according to the data availability, we extended the sample period of our main model to 1980–2014. As the FD2 index had relatively complete data compared with other indexes in the earlier years, we used FD2 as the proxy of financial development and extended the initial sample period from 1990 to 1980, 1970, and, 1960, separately.

Table 13 shows that the coefficients of FD1 and FD2 were all positive and strongly significant, which implied that the previous results were valid in the long-term. We estimated the first three regressions with the same system GMM; however, we estimated the last regression (FD2, 1960–2014) using the least squares dummy variable corrected (LSDVC) method, as the sample data of this regression were long panel data (the number of years was larger than the number of countries); therefore, the estimated values would have appeared to have a serious bias if we used GMM. LSDVC performs much better than GMM under this circumstance [56,57].

Table 13. Results of the full sample regressions with longer periods.

	FD1	FD2		
Variable	**1980–2014**	**1980–2014**	**1970–2014**	**1960–2014**
L.CE	0.4839347 *** (0.1067562)	0.4383872 *** (0.1034471)	0.7236401 *** (0.0732967)	0.884147 *** (0.00817)
FD1/FD2	1.6262826 *** (0.3733870)	0.3344634 *** (0.0744378)	0.1983611 *** (0.0679762)	0.0323547 *** (0.0102972)
TRADE	0.1824042 *** (0.0658842)	0.126911 (0.0793001)	0.0421382 (0.0570367)	0.0560654 *** (0.0143864)
URBAN	0.6113399 *** (0.1382679)	0.6844983 *** (0.1324414)	0.1865905 (0.1533993)	0.0215443 (0.0183576)
POP	−0.0870749 *** (0.0282710)	−0.0605956 * (0.0335829)	−0.0200851 (0.0199274)	−0.0012604 (0.008534)
IND	0.3701238 *** (0.0960192)	0.4382745 *** (0.1244763)	0.1286947 (0.1215409)	0.0285649 *** (0.010906)
Constant	−4.4280447 *** (0.9307957)	−5.436065 *** (1.070145)	−1.887942 *** (0.5800526)	-

Table 13. *Cont.*

	FD1		FD2	
Variable	**1980–2014**	**1980–2014**	**1970–2014**	**1960–2014**
No. countries	90	81	58	41
AR (1)	−3.75 *** (0.000)	−3.39 *** (0.001)	−3.79 *** (0.000)	-
AR (2)	−0.40 (0.688)	−1.09 (0.277)	−1.25 (0.213)	-
Hansen test	73.58 (0.244)	71.15 (0.310)	42.11 (0.423)	-

Note: ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

6. Discussion

As most of research on the relationship between financial development and carbon emissions focuses on specific countries or regions, our study analyzed their relationship from the global perspective with worldwide cross-country panel data, and investigated the national difference by dividing the country samples into two sub-groups, besides, we further examined the effect of different aspects of financial development on carbon emissions with a series proxy variables, under a unified framework. Therefore, compared with the previous research, our study could provide a macroscopic intuition and more empirical evidence on this topic. Although our conclusions were consistent with some research [22,23,28], they were quite different from other works [16,17,27]. As mentioned above, the controversial conclusions reflect the complexity of the relationship between financial development and carbon emissions, which may vary across countries or regions, therefore it is unreasonable to hold a constant opinion, and additional in-depth research is needed on this topic.

The main limitation of our research was, we investigated the national difference of the effect of financial development on carbon emissions by dividing the country samples into two sub-groups, however, due to the inadequate data and the lack of relevant research, we could not conduct more accurate analysis on it. Specifically, the controversial results obtained by research on this topic (including our study) actually reflected the nonlinear characteristics of the relationship between financial development and carbon emissions to some extent. In other words, there might exist one or more factors which could significantly affect the relationship between financial development and carbon emissions. These factors could be concrete ones such as institution and policy, or a general concept such as income level or development level of a country. This might be an interesting and worthwhile research direction that scholars have rarely focused on.

7. Conclusions and Policy Implications

In this study, we empirically researched the relationship between financial development and carbon emissions based on the data of 155 countries, and analyzed the national differences by dividing the sample countries into two sub-groups: developed countries, and emerging market and developing countries. Besides, we further investigated the effect of different aspects of financial development on carbon emissions by adopting a series of proxy variables. According to the empirical results, we concluded that the financial development can increase carbon emissions from a global perspective, and this conclusion remains valid for the sub-group of emerging market and developing countries. However, the empirical results indicated that financial development has no obvious influence on carbon emissions for developed countries. Besides, compared with the development of stock market, the development of financial institution has a relatively stronger effect on carbon emissions. The robustness checks proved that the above empirical results are reliable.

The empirical analysis suggests the following policy implications:

(1) Over the past few decades, the growing carbon emissions have become a global environmental issue which received widespread attention. According to the data of World Bank, the world's metric tons per capita carbon emissions is 4.19 in 1990, but dramatically increased to 4.97 in 2014. Although some research considers that the financial development could reduce carbon emissions and find empirical evidence in several countries or regions [9,15,16], our analysis indicated that the financial development has a positive effect on carbon emissions from the global perspective, which means the development of the financial sector cannot be intuitively deemed as a measure to address environmental degradation, and policymakers should carefully analyze the environmental effects of financial development and balance this relationship based on specific circumstances of a country.

(2) The empirical results of the sub-groups indicated that in emerging market and developing countries, the financial development has a positive effect on carbon emissions while it has no obvious influence in developed countries. These are consistent with the conclusions of some research [14,23,28]. This implies that with the increase in the development level of a country, the "positive effect" of financial development on carbon emissions will be gradually offset by the "negative effect".

Generally, the developed countries have well-developed industrial systems that enterprises tend to invest in technological innovation but not scale expansion, and the financial sectors prefer to fund for environmental protection projects due to the strict environmental regulations of government. These could largely neutralize the "positive effect" of financial development. Consequently, policymakers in developed countries are not facing environmental pressure while planning the development of the financial sector, which will enable them to concentrate on the function of resource allocation and growth effect of financial development.

Nevertheless, due to the undeveloped industrial sectors and the pressure of economic development in emerging and developing countries, the enterprises tend to expand production scale though credit rather than developing energy saving technology, hence the "positive effect" of financial development dominates and the development of financial sector has a significant effect on carbon emissions. This reflects the unavoidable contradiction of economic development and environmental protection. Notwithstanding, we suggest the policymakers in emerging and developing countries to carefully balance their relationship and attach importance to emission reduction, as the extensive growth will conversely impede the long-run economic development, meanwhile, it will dramatically increase the cost of environmental pollution control in the future. Specifically, it might be reasonable for governments to lead more financial resources for industrial upgrading, which could improve production and energy efficiency and finally promote economic growth from the channel of total factor productivity (TFP) [58], along with the reduction of carbon emissions.

In addition, the empirical results of the sub-groups also implied that the influence of financial development on carbon emissions might agree with the law of short-term pain, long-term gain, from the macro perspective. Therefore, policymakers in emerging market and developing countries could comprehensively regard the positive effect of financial development, and formulate a long-term strategy for the domestic development of the financial sector.

(3) The empirical results of regressions with different proxy variables of financial development reflected that the development of stock market has obviously smaller influence on carbon emissions than the development of financial institution. This may be caused by the strict supervision of listed companies which enforce them to assume social responsibility of environmental protection and utilize more advanced technologies which could increase the energy efficiency and reduce carbon emissions. Therefore, the authorities might consider giving a priority for the development of the stock market, as it performs better to limit the increase of carbon emissions, compared with the development of financial institution.

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Appendix A Sample Countries and Classification

We expanded our country sample to the utmost extent in order to enhance the reliability of empirical results. However, we had to drop several countries due to the significant missing data and obtained a sample of 155 countries. Table A1 presents the sample countries by different groups.

Table A1. Sample countries and classification.

Developed Countries				
Australia	Austria	Belgium	Cyprus	Czech Republic
Denmark	Estonia	Finland	France	Germany
Greece	Hong Kong SAR, China	Iceland	Ireland	Israel
Italy	Japan	Korea, Republic	Latvia	Lithuania
Luxembourg	Macao SAR, China	Malta	Netherlands	New Zealand
Norway	Portugal	Singapore	Slovak Republic	Slovenia
Spain	Sweden	Switzerland	United Kingdom	United States
Emerging Market and Developing Countries				
Albania	Algeria	Angola	Antigua and Barbuda	Argentina
Aruba	Azerbaijan	Bahamas	Bahrain	Bangladesh
Barbados	Belarus	Belize	Benin	Bhutan
Bolivia	Bosnia and Herzegovina	Botswana	Brazil	Brunei Darussalam
Bulgaria	Burkina Faso	Burundi	Cabo Verde	Cambodia
Cameroon	Central African Republic	Chad	Chile	China
Colombia	Comoros	Congo, Democratic Republic	Congo, Republic	Costa Rica
Cote d'Ivoire	Croatia	Dominica	Dominican Republic	Ecuador
Egypt, Arab Republic	El Salvador	Fiji	Gabon	Gambia
Georgia	Ghana	Grenada	Guatemala	Guinea
Guinea-Bissau	Guyana	Haiti	Honduras	Hungary
India	Indonesia	Iran, Islamic Republic	Jamaica	Jordan
Kazakhstan	Kenya	Kyrgyz Republic	Lao PDR	Lebanon
Libya	Macedonia, FYR	Madagascar	Malawi	Malaysia
Maldives	Mali	Mauritius	Mexico	Moldova
Mongolia	Morocco	Mozambique	Myanmar	Namibia
Nepal	Nicaragua	Niger	Nigeria	Oman
Pakistan	Panama	Paraguay	Peru	Philippines
Poland	Romania	Russian Federation	Rwanda	Saudi Arabia
Senegal	Seychelles	Sierra Leone	South Africa	Sri Lanka
St. Kitts and Nevis	St. Lucia	St. Vincent and the Grenadines	Sudan	Swaziland
Tajikistan	Tanzania	Thailand	Togo	Tonga
Tunisia	Turkey	Uganda	Ukraine	United Arab Emirates
Uruguay	Vanuatu	Venezuela, RB	Vietnam	Zambia

In order to study the country specific effect of the influence of financial development on carbon emissions, we divided the sample into two groups, namely developed countries and emerging market and developing countries, this is based on the country classification of International Monetary Fund (IMF) [59]. Compared with other classification criterion, the characteristics of different types of countries was comprehensively considered rather than a single aspect or indicator, and it has been widely adopted in empirical research, such as von Hagen and Zhou [29], Donadelli and Paradiso [30], and Wu et al. [31].

It is necessary to explain that we used the word "country" in this article for simplicity, actually it refers to "country and region", which included special administrative regions et al.

Appendix B The Introduction of the Index Proposed by Svirydzenka (2016) (FD1)

We used the comprehensive index of financial development proposed by Svirydzenka [41], to be one of the proxy variables of financial development. This index is constructed using six sub-indexes, concerning the depth, access, and efficiency of financial institutions and markets. Table A2 presents the framework of this index.

Table A2. Framework of the index proposed by Svirydzenka [41] (FD1).

Aggregate Index	First-Level Sub-Index	Second-Level Sub-Index
Financial Development (FD)	Financial Institutions (FI)	Depth (FID)
		Access (FIA)
		Efficiency (FIE)
	Financial Markets (FM)	Depth (FME)
		Access (FMA)
		Efficiency (FME)

Source: IMF website [60].

Svirydzenka [41] divided financial development into two aspects: financial institutions and financial markets, then measuring each aspect from the angles of depth, access, and efficiency. By adopting a series of original indexes and methodologies, the author first computed two first-level sub-indexes, namely financial institutions and financial markets, then computed the aggregate index—financial development based on the first-level sub-indexes. Due to the length limitation, we do not further introduce the detailed construction process of this index, please refer to the original manuscript of Svirydzenka [41] for the complete information. The data of index can be extracted from the website of the IMF [60].

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Reducing the Carbon Footprint of the Bucharest University of Economic Studies through Green Facades in an Economically Efficient Manner

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Abstract: This paper focuses on the current environmental issues, more specifically the amount of greenhouse gases humanity is being confronted with at the moment. The research was carried out on a niche of the topic, namely on the carbon footprint of public buildings. The concept of a sustainable university is new and insufficiently explored, and as part of the environmental metabolism, it influences anthropic sustainability in a directly proportional manner. This indicator's monitoring systems reveal how vulnerable humanity is in front of the latency of an unprecedented and inevitable environmental catastrophe. The ecological effects may be mitigated by the academic community through green urban design. The ecological performance can be expressed in an economically efficient manner, which can, at the same time, create a precious channel of communication within the entire academic community though volunteering for sustainability. Moreover, this research has identified several solutions for optimizing the carbon footprint, which do not hinder the necessary economic development. Within the current context, when most economic activities are leading to ecological collapse, sustainability should be reprioritized with the help of the academic society, through the examples offered by applied research. The premises of this research were represented by bibliometric analyses and the results obtained have proven its importance, as well as the importance of certain scenarios involving solutions for improving the metabolism of nature.

Keywords: sustainability; sustainable university; ecological collapse; climate change; green vertical facades

1. Introduction

Environmental, social and ethical incidents are currently occurring more and more frequently worldwide, generating environmental costs and repercussions that are difficult to correct in the short and medium term. Up until now, academic research focusing on reducing the carbon footprint has not had a significant impact due to the lack of communication between society and the academic environment. This research study intends, on the one hand, to propose economically efficient solutions for improving the way in which academic institutions communicate their findings related to the reduction of the carbon footprint, and on the other hand, to involve the whole academic community in a dialogue with society at large. At the international level, applying the solutions proposed by this research can generate a sustainable micro environment in any academic unit.

Romania has been chosen for this case study because its living standard is considered to be one of the lowest within the European Union and because it is in dire need of improving various environmental-related aspects, in spite of having been the first Eastern European country to sign the Renewable Energy and Energy Efficiency Partnership.

The carbon footprint, which represents the most influential component of the ecological footprint [1], is the indicator that should be optimized in the short term in order to impact climate change in a positive manner. The metabolism of the environment is closely connected to the carbon footprint, which, in its turn, is influenced by the quantity of carbon released into the air, as part of the greenhouse gases. This indicator, which has recently started to be monitored, comes as a response to the people's need to perform their activity in a safe and sustainable environment, beneficial for both the current generation and the ones to come.

The objective of this paper is to prove that when trying to reach a global objective, small actions can have a strong impact due to their capacity to repair the erroneous approaches adopted in comfortable times. One of the main causes that carbon is released into the air we breathe is related to the instinctual or irresponsible type of consumption and this is true overall, not only when referring to Romania.

The economic efficiency model of sustainability, specifically the reduction of the carbon footprint, can be communicated through the empirical method of the example, by, which the academic communities demonstrate the applicability and efficiency of a lifestyle guided by the principles of sustainability.

During the first world conference on air pollution, which took place in Geneva in 2019, various statements were formulated about how people's health is affected by this type of pollution. The conference was jointly organized by the United Nations, the World Bank and the European Commission, and representatives of these institutions presented initiatives that gave humanity a series of objectives to reach by 2030, the main focus being that of having nearly zero carbon emissions.

At this moment, air pollution in households represents an important cause for why an increasing number of people are developing illnesses, such as various types of pneumonia or other infections of the lower respiratory tract, which is an indication for researchers that concrete solutions are necessary in order to meet the needs of the modern world.

In terms of deaths caused by air pollution, it has been proven that the emissions produced by industrial activity, cars and trucks have a higher impact on people than the air pollution in households.

Since the international and domestic legal framework oblige all the levels of society, public and private alike, to rationalize the use of resources (especially fossil fuels) and to reduce the current carbon levels, this is no longer a mere indication to change the approach used so far, but an emergency.

The first part of this paper offers an overview of the theoretical approaches of the past 50 years from three points of view—the historical perspective, the correlation with globalization and the importance of the carbon footprint of public buildings. Although these are not dwelling places, people spend around 8 h per day on average there.

The cost–benefit analysis for green buildings will then be compared and contrasted with the environmental cost–benefit analysis. This aspect was studied because the publications on this topic have been insufficiently turned to account in Romania, the present paper indicating a desire to evolve, to be proactive and to apply the proposed actions.

Green vertical facades are not new in the world, but it is a fact that they can ensure protection to a building, reduce its carbon footprint and bring many other benefits in a limited urban space. The trend of green vertical facades was popular in North America and Western Europe at the beginning of the 19th century, but the sun or acid rains destroy them over time, so due to the fact that their maintenance was not economically efficient at that moment the trend became unpopular [2] (pp. 423–236).

The academic literature mentions that noise pollution, urban heat pollution and air pollution can be mitigated through green facades, which can, moreover, bring energy-saving benefits [3–6].

Further on, the paper refers to public buildings. Two of the buildings in the complex of the Bucharest University of Economic Studies (henceforth referred to as BUES) were chosen in order to demonstrate their green potential.

After the theoretical documentation and considering the results of the calculations, short conclusions have been drawn, highlighting the fact that when acting in a mature, informed and responsible manner, solutions can be found, adapted and applied.

The importance of this paper lies in the topical character of the research and in providing a solution to one of the most important challenges worldwide.

The research was based on several research platforms and calculators of the carbon footprint.

2. Materials and Methods

2.1. Theoretical Approaches of the Carbon Footprint Concept in the Context of Globalization

The world today is operating within an ever more tightly interconnected economic system made up of scenarios, models and sub-systems, widely known as globalization. Although humanity's aim is to eliminate the disparities among the countries worldwide, the development trend is unequal, with each country, be they Asian, American or European, using different strategies to achieve prosperity [7]. The current dynamism represents a challenge for the decision makers at the government level to find a balance between the economic objectives and the way to reach them while avoiding the destroying of the environment.

The present research is based on a bibliometric analysis using the content on the Scopus platform, covering the time interval between 1962 and now. The reference year 1962 was chosen because this was the moment when the subject of air pollution and sustainability began to attract the attention of the general public, also including the years that preceded the 1970 oil crisis. The year of 1962 was also the year when the book "Silent Spring" was written [8], as a first attempt to explain sustainable development through green facades.

The present research study took 452 papers into consideration. The bibliometric analysis, which was made with the help of the VosViewer software version 1.6.7. (Leiden University's Centre for Science and Technology Studies (CWTS), Leiden, Netherlands), shows that universities all over the world are researching this field, with the academic environment of the United States of America registering a total of 132 published articles and Kyung Hee University of China nine published articles, while in Romania there is only one article published on this topic, by Gheorghe Asachi University in Iași. Considering that in this Romanian study there is no reference to the applicability of the activities related to sustainability in a model of economic efficiency, the present article aims to make a specific contribution in this field.

With the beginning of this millennium, the amount of raw materials and of intermediary or final products of various complexity levels (most of them being at the high end of this scale) have increased their presence in the soil, water and air [9]. This is an alarming aspect, urging for better waste management.

The current world context is characterized by an unprecedented dynamism, which calls for monitoring, so that the environment indicators would reach an optimal level. Over the last few decades, the institutional changes and the evolution of the social and political relationships alongside the environmental issues have become more and more interconnected [10].)

The approach towards a global economy from the consumption viewpoint, supported by the accelerated pace of technological advances, has led to the degradation of nature, as indicated by several alarming situations that can degenerate into catastrophes within a short time span.

Specialized literature signals frequent, subtle issues, which draw attention to pollution, such as the outsourcing of production by the technologically advanced, financially powerful countries to so-called emerging states that are almost industrialized, thus creating the illusion of a win-win system, where all the parties involved have to gain. This point of view takes into consideration only the material aspect, while the long- and medium-term costs associated with the pollution of the environment for obtaining a global manufacturing system are often neglected [11].

The current geographical constraints generate difficulties in managing the environment, a fact that was also noticed by Waters in his 1995 impactful publication [12].

The current climate variations unveil the effects of perpetual pollution, and this change in the seasons does not come solely with psychological discomfort, but also with warnings about the ever-higher incidence of diseases and the existence of certain types of viruses, which are more aggressive and more resistant than ever before. One should also note the existence of both political and social voices militating for optimizing the indicators and ensuring ecological sustainability.

The answer given by the contemporary business world to the driving forces of globalization currently depends on the influence of environmental pollution. The effective management of a sustainable economy in an unpredictable context requires that the global policies should be restructured, so that the responsibility to ensure sustainability is no longer just a research concept, but a task attributed to continents, countries, organizations and individuals. Thus, the business schools and economic research centers are made accountable, since their approach is threefold, involving at the same time the social, economic and ecological components, coupled with monitoring the global attitudes in these three areas [13].

Such statements related to threefold decisions (from the point of view of the social environment involved) are to be found in specialized literature since 1992. This observation was made by William Rees, who draws attention to how the approaches have changed over the past few years. These changes are remarkable, because nowadays the political approach is threefold, including the economic environment, the natural environment and the social environment [14]. Due to the fact that two of the variables (economic and social) have undergone changes induced by the change in world consumption, with the help of globalization, the third variable has been implicitly affected as well, requiring to be prioritized on the list of issues humanity is currently being confronted with and that need to be solved.

The pressure of the race against time to reduce pollution and to obtain close to optimum levels of the indicators that reflect these concepts has currently led to intense debates related to individual instinct versus ethics as far as consumption and capitalism are concerned, since the ratio between the available resources and the world population, which is on an exponential increase, is deeply disproportionate. In its turn, this creates economic and health-related issues in a world where the accelerated pace of innovation does not seem to suffice.

The specialized literature describes globalization and sustainability as two concepts that require the attention of decision makers, since the economic and technological exponential growth has reached a critical point in destroying the environment [15].

The carbon footprint is an innovative concept popularized in Europe in the early 2000s, which describes the assessment of a limited life or production cycle. The scientific world unanimously accepts it as an indicator referring to the monitoring and interpretation of a segment of the greenhouse gases, namely the high concentration of carbon, which is aggressive to the environment [16]. The common denominator for measuring and calculating it was proposed at the international level by The United Nations Environment Programme - Sustainable Building and Climate Initiative (UNEP-SBCI), which further proposed the Common Carbon Metric (CCM) [17].

A notable document and international conference in the field is the Kyoto Protocol, which was negotiated in 1997. In parallel, there was an impressive civic mobilization, when numerous companies and individuals voluntarily committed themselves to reducing and compensating their own greenhouse emissions. This historical event focused on the flexible economic mechanisms meant to help maintain the optimal levels of the parameters indicating the emission of greenhouse gases into the atmosphere [18].

The voluntary compensation market is dynamic and experiencing an exponential growth, and is worth approximately 10 million tons of carbon dioxide resulting from the already traded carbon offset projects run so far. The voluntary financial compensation projects, which do not fall under the provisions of the Kyoto Protocol, are often characterized as small, diverse and innovative, the last two attributes representing a potential source of wealth. However, the lack of clarity, the confusing and poorly defined stipulations and traceability of products may allow projects of doubtful quality to reach the current market [19].

More than 20 years ago, Jeffrey Amthor maintained the fact that this accumulation of climate variations and changes is due to the increase in the carbon dioxide emissions (CO_2) into the atmosphere, but that it was not easy to find direct evidence in support of this theory [20].

In the literature we can find the ”ark syndrome” concept, which highlights the issue of the continuous economic growth and the elimination of its expansionist borders [21], due to the fact that this growth must be supported by resources and until the time an unlimited source is tapped, this desire remains a utopia.

A traditional approach considers only two types of resources, namely: fossil fuel-generated energy and the accumulation of raw materials. By nature, these are exhaustible, namely the more you use them, the faster they will be consumed. On the other hand, the technological advances have brought about the information society, which is currently advancing towards the knowledge society. The academic voices are thus raising hopes at the macroeconomic level by means of academic research, which represents a catalyst in implementing the new technology at the society, organization and individual level [22].

The access of humans to new energy sources has been a concern for some time. As the fossil fuel reserve is more and more affected and more and more greenhouse gases are produced, using green, technologized and easy to apply energy is the solution that humans need on a large scale in order to access sustainable energy resources [23].

There are frequent discussions in the academic world about an imminent economic collapse. The reason for this imminence is represented by the need for a better management of the environmental factors. If this need is not met, there will be an ecological collapse, because both the much-desired economic growth and the speedy technological development are taking place in an unstable biosphere with numerous “sensitive points”.

At the moment, sustainability is one of the great world challenges, and air pollution, namely keeping the carbon footprint within optimal limits, is inviting the political decision makers to an intense, wide and prompt reflective process with a view to conserving biodiversity.

The transition to this new paradigm is pushing the responsibility downwards on the social pyramid. At the moment, the pollution issue is no longer an abstract concept for the small businesses or for the individual, since every economic unit is fully and directly accountable for the carbon footprint level [24].

During the past decades, studying the carbon footprint was considered essential. In 1992, at British Columbia University, Professor William Rees introduced this concept for the first time, defining its content and limitations. He stated that the level of the world carbon footprint is by far higher than the regeneration power of the planet, considering the estimated pace and consumption frequency at that moment in time, which are also valid today [14]. Therefore, many academics studying this topic or sustainability-related topics recommend that the analysis of the carbon footprint indicators and implicitly of air pollution should be correlated with the consumption behavior, which is now characterized by volumes, versatility and unpredictability. Therefore, continuing this consumerist style supports the exploitation of both the economic and the natural environment.

Roberts maintained that, to a varying degree, pollution is determined by the behavior of individuals, who, while performing daily or tourist activities, are directly involved in keeping an optimal level of the aesthetic, sanitary, hygienic and recreational functions of the environment [25]. Later on, academic research evolved, coming to underline the fact that the generated carbon footprint was higher at the community level as compared to the one produced by transnational companies.

The concept studied in this paper was created with a clear purpose, namely of monitoring and calculating an essential aspect of durability: the extent to which the productive ecosystems of this planet can satisfy the new types of need that appeared over the past 50 years in a balanced way, proportional to the power of regeneration of the resources [26].

The term durability has been present in the vocabulary since antiquity, but its semantic valences are different now, when, at the start of the millennium, we are talking about durable development, which is a new concept. It describes the evolution of the human civilization in agreement with the optimal parameters of the ecosystem, avoiding damaging their level, with the intention of passing on a healthy environment to the next generations, suitable for their development, which is a challenging matter given the demographic boom [27].

In Romania, in 2008, the specialized literature mentioned the fact that the carbon footprint concept relies on a calculation of the planet's regeneration capacity, at a time when humanity is set only on using the available resources and not on conserving or using them in a sustainable manner [28].

Nowadays, sustainability is no longer understood as made up of strictly punctual issues, but as an overall concept covering the whole system of life.

2.2. Theoretical Approaches of the Carbon Footprint of Buildings

The carbon footprint concept allows researchers to study the consumption patterns from a new perspective, in order to obtain a more realistic image of a country's ability to meet the people's needs and its capacity to regenerate and keep producing such resources over a determined period of time (most researchers use the 1 year standard).

The increased flexibility of the offer available on the market is due to the redundant commercial channels, which offer the final client a high degree of freedom in terms of options, which is also extrapolated in terms of energy consumption [29].

It is worth mentioning that at the moment all the European Union Member States are being confronted with more or less significant ecological deficits. By comparison, Romania is still enjoying an optimistic value, lower than the average of other EU Member States, of approximately 2.4 global hectares (gha) per capita, although the consumption behavior patterns are indicating a worrying upwards trend [28].

The main variables that influence the carbon footprint level are related to the means of transport an individual or organization frequently opt for, the eating pattern adopted, the non-food items consumed and, last but not least, the household energy consumption [30].

The household could be described as a space where activities are performed, since it is a generic term for the building where the companies perform their daily activities. The big carbon footprint generators are the public buildings, such as city halls, schools, hospitals, boarding houses, etc.

Worldwide, buildings, and more specifically their energy consumption, account for 40% of the volume of carbon released into the atmosphere [31].

There is a stringent need for the decision makers at the international community level, as well as at the national level, to become involved, since at the moment there is no legal framework with clear stipulations about how to deal with the carbon pollution produced by non-industrial buildings. At present, such buildings are regulated by two relatively recently amended directives, one referring to ecological design and the other related to the buildings' ecological performance [32].

It is essential that a debate should be organized on the topic of energy efficiency, because Romania's fossil resources are plummeting, which is making the country dependent on imports. This dependency has been dramatically increasing over the past years and it is prompting the media to produce scenarios referring to an "economic colonization" of this country [33].

The directive on the ecological performance of buildings introduces the concept of a low energy house or building, this notion being defined by an energetic consumption close to zero, thus highlighting the importance of using green energy, not only at the research level, but also on a daily basis. A low-energy building is the one inside of which we can be comfortable irrespective of the season without using a conventional source of energy, the focus being on climate control [34].

This legal provision is also coming with a deadline (31 December 2020) by which the Member States must comply with a high-energy performance level. This way, the issue reaches the economic world, the companies being forced to find a balance between the costs and the environmental benefits generated, because these must be assessed in the long run, throughout the life span of a building [35].

Although the biggest impediment faced by the economic agents in this respect is of a financial nature, one should not neglect the opportunities offered by this framework. It makes it possible to identify the sensitive aspects within the living spaces, with a view to identifying and controlling the risks, as well as to obtain a lower, limited and controllable consumption of the resources, generating savings in the long term. Likewise, in terms of local and regional public health budgets, the costs allotted for treating lung, cardiac and digestive diseases will go down over time as a consequence of lower air pollution levels.

Another opportunity that is better used by corporations is that of consolidating the image of the institution or locality, since the marketing department can use this process in order to consolidate an environmentally friendly brand, in response to the market demand for ecological performance.

The unprecedented economic progress seen by humanity over the past century has fostered consumption in its various forms, even at the energy level. At the moment, redirecting the consumption is a matter of concern, given the fact that the demographic boom is not likely to lead to its decrease [36].

In Romania, the nature of the habitat in rural areas imposes specific strategies, because there are still isolated houses, the dispersion of buildings being quite high. Due to the demographic characteristics of rural areas, the conventional, low voltage electricity system can be avoided by means of individual installations using green energy from renewable sources. The economic scenarios produced in this respect are positive from the viewpoint of the costs involved, but only over a longer period of time of around 20–30 years. However, creating such a network implies a big investment from the local budget, since the related costs are substantial [37].

Thus, the discussion in the academic environment starts with the basic heat transfer and heat absorbing construction elements (green energy proposes the ones that absorb the solar heat and light) and continues with designing the tools that will produce the desired effects [38].

Even within this niche of the energy domain there is a sub-niche that proposes the use of solar energy by means of solar loops or heat pumps that are connected only to the source element of solar heat [39]. These studies and proposals are fostering the further development of specific equipment with a warranty that would seem utopian in a consumerist age, namely for life.

The political reforms initiated after 1989 had the purpose to dismantle monopolies and to decentralize the economy by privatizing its main units, thus creating the framework for the development of a necessary niche [40] for renewable energy, which, with social and economic support, should grow out of its current ”niche energy” status during the following years.

Although the renewable energy actors have earned their right to compete on the market, this right cannot be properly turned to account in the absence of government tools, which are properly supported and popularized.

The development strategy of Romania for 2016–2035 addresses, inter alia, the bioenergy sub-sector (biogas, biomass, biofuel) and biotechnologies of environment [41].

Romania was a pioneer within the European Union, being the first Eastern European signatory of the Renewable Energy and Energy Efficiency Partnership. The calculations of the Ministry of the Environment describe the renewable energy production capacity as follows: 65% of it would result from biomass, 4% from the sun and 1% would be voltaic and geothermal, although the geothermal source is a prolific one [42]. However, another impediment for the real economy lies in the fact that the workforce has emigrated during the past 30 years and the offer of skilled staff for installing, mounting and maintaining such equipment is fairly low, and consequently, according to the economic laws, expensive.

During the past three decades, significant steps have been made to create new methodologies, tools and equipment, which would systematically support the environmental strategies with a view to putting the green energy innovations into practice. Nowadays we have a better understanding of how human actions are impacting the environment [43]. Even if each individual on the planet is faced with the carbon footprint challenge, the ensuing responsibilities are not clearly defined, at least from the quantitative viewpoint. It is most likely that the future will bring these clarifications, once the public expectations increase as a consequence of the severe climate change.

3. Applying the Method of Reducing the Carbon Footprint in the Case of the Bucharest University of Economic Studies in an Economically Efficient Manner

The prospects for reducing the carbon footprint in the public sector should not be considered only as involving extensive initial changes, since the concern for the environment can also be shown by means of low cost changes that may bring generous image benefits, as well as environmental advantages. An environmental cost–benefit analysis is difficult to perform because of the limitations due to the lack of data in this field. It is worth mentioning that a ton of carbon dioxide currently costs 13.67 euros.

In order to reduce the carbon footprint generated by the Bucharest University of Economic Studies, the approximate current situation of two bodies in the complex of the institution was taken into account. Reducing the carbon footprint of the BUES community, which consists of 23,000 people, would generate a special impact.

The first implementation proposal, in response to the need for the buildings with a public purpose to become more eco-friendly, involves placing a vertical garden on one of the facades of BUES, which would generate marketing opportunities and other advantages.

The second proposal is based on the desire of the students from the NGO of the Faculty of AgriFood and Environmental Economics to trigger a change of lifestyle and lay the foundations of some activities meant to set a long-term example for the Bucharest student community involved in ecology.

The Current State of the Buildings

The researched area is located in the urban space of the municipality of Bucharest. The dimensions of the researched buildings within the Bucharest University of Economic Studies are the following: Building A: 5612 square meters and Building C: 715 square meters (1500 square meters with yard).

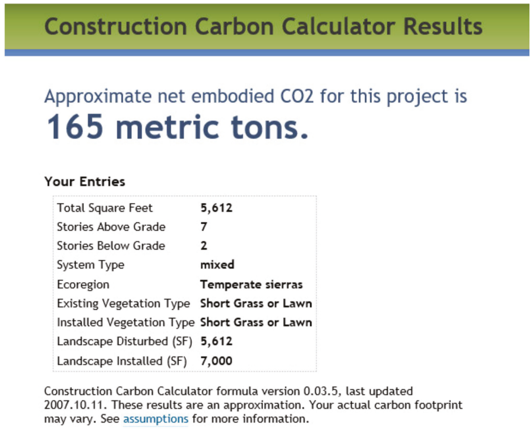
Both buildings have nine levels, seven on aboveground and two underground, each level summing up to 623.56 square meters. The structure system is a mixed one (concrete, steel, wood, etc.). Moreover, in the surrounding area there are fruit trees (seven apple trees, seven cherry plum trees, two plum trees, two cherry trees, one mulberry tree and shrubs).

No additional access routes are proposed, as the location benefits from several entrances and exits, being situated in the immediate vicinity of an important intersection.

In case of an earthquake, structural degradation may occur, but it would not risk destabilizing the construction. Currently, the buildings are connected to all the utilities systems that use conventional energy, all being functional. The climatic factors in the area where the buildings are located do not represent an investment risk.

With the help of Romania Green Building Council and Build Carbon Neutral, the footprints of the Bucharest University of Economic Studies Buildings A and C were estimated, using the software made available online (Figures 1 and 2 [44]).

This software estimates the carbon that is embodied in the construction, and it is used as a tool in the management of the carbon footprint reduction. It takes into consideration the site, the landscape and the eco installation disturbance, and it requires basic information regarding the technical aspects of the building irrespective of whether it is a public one or a household. The results it provides refer to the carbon footprint of a building as a whole and they are ±25% accurate. In our specific situation, it is important to mention that the carbon footprint of the underground levels is embodied in the stories above the ground. One argument in favor of using such software is that, for example, 13% of the global carbon footprint is generated by transportation, while the carbon footprint of buildings accounts for 19% [17]. In this way, a holistic approach can be obtained when assessing the pollution generated by any type of building, be it public or private (household).



Construction Carbon Calculator Results

Approximate net embodied CO2 for this project is

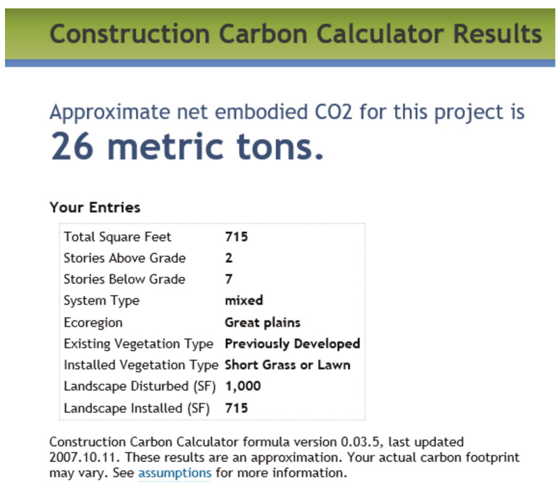
165 metric tons.

Your Entries

Total Square Feet	5,612
Stories Above Grade	7
Stories Below Grade	2
System Type	mixed
Ecoregion	Temperate sierras
Existing Vegetation Type	Short Grass or Lawn
Installed Vegetation Type	Short Grass or Lawn
Landscape Disturbed (SF)	5,612
Landscape Installed (SF)	7,000

Construction Carbon Calculator formula version 0.03.5, last updated 2007.10.11. These results are an approximation. Your actual carbon footprint may vary. See assumptions for more information.

Figure 1. Calculation of the carbon footprint of Building A, the Bucharest University of Economic Studies. Source: www.buildcarbonneutral.com [44].



Construction Carbon Calculator Results

Approximate net embodied CO2 for this project is

26 metric tons.

Your Entries

Total Square Feet	715
Stories Above Grade	2
Stories Below Grade	7
System Type	mixed
Ecoregion	Great plains
Existing Vegetation Type	Previously Developed
Installed Vegetation Type	Short Grass or Lawn
Landscape Disturbed (SF)	1,000
Landscape Installed (SF)	715

Construction Carbon Calculator formula version 0.03.5, last updated 2007.10.11. These results are an approximation. Your actual carbon footprint may vary. See assumptions for more information.

Figure 2. Calculation of the carbon footprint of Building C, the Bucharest University of Economic Studies. Source: www.buildcarbonneutral.com [44].

The value calculated by the software is a rough one, vitiated by the limitations of the research, but it provides the essentials regarding the worryingly high values of the carbon pollution, which slowly affects the community of 23,000 people and more.

Even if at first sight the value for Building C seems optimistic, one should take into account both the proportionality with the built surface and the fact that this construction benefits from a large garden of 1500 square meters.

From a comparative perspective, the optimal annual value of the carbon footprint is 2 tons per year per person. The average footprint of a European person is 10 tons per year.

In an optimistic scenario, the national governments and European officials rely on reducing the use of conventional energy and increasing the use of clean, green energy by 2050.

However, it should be mentioned that although efforts are being made to implement measures that will lead to a rise in the use of green energy, producing and/or using it is still creating pollution (Figure 3 [45]).

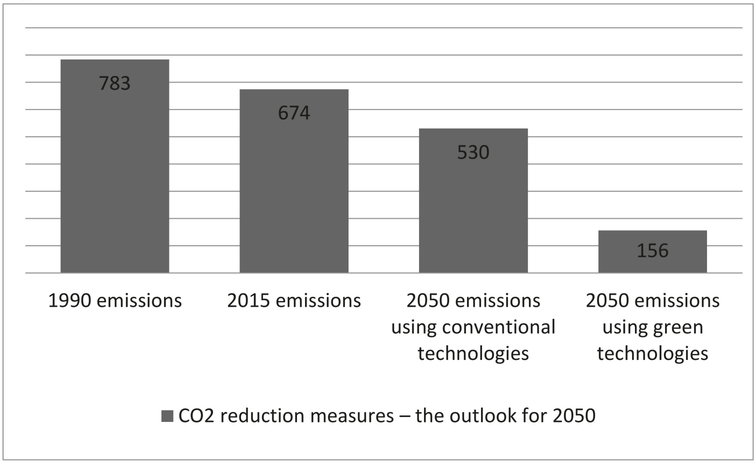


Figure 3. CO2 reduction measures—the outlook for 2050. Source: CEMBUREAU [45].

In order to mitigate the consequences produced by the high values of the indicator analyzed in this paper, the construction of a vertical garden of 100 m^2 was considered, followed by the setting up of an urban garden on the sixth floor of Building A, supported by volunteering and public or private funding. Additionally, its maintenance costs could also be covered by attracting public or private funds.

4. Results

The two proposed constructions (i.e., vertical garden and urban garden) are part of a relatively new eco-landscape concept. According to statistics, over 80% of this kind of buildings were created after 2007, and over 93% of the urban gardens were built after 2009. They can be built indoors as well as outdoors.

This concept is relatively new because although it was patented in the US in 1938, in Europe it has only started to become popular in the 1980s. The largest project of this kind, consisting of a wall covered with vegetation with an area of approximately 2700 square meters, can be found in Mexico.

The construction of a vertical garden

When it comes to urban gardens, it is essential to consider that they are of three types:

- Green facade;
- Living wall;
- Support wall.

A green facade is a plant system that often requires a special microclimate regime. In the case of high buildings, the plants are planted in the ground at the base of the construction, or in strategically placed pots, being expected to meet their objective of shading and preserving the temperature after several seasons.

Living walls consist of panels with plants that were previously mounted on them, their advantage as compared with a green facade being density. The preferred plants for this type of installation are the perennial or aromatic ones. Because the panels are modular, they are highly flexible and adaptable to the climatic conditions, resisting both in arid areas and in those with a high level of humidity.

Green support walls are the most elaborate construction, their purpose being to attenuate the slopes at an angle greater than 45 degrees but less than 88 degrees. At the base there are tiles made of different materials, previously filled with the type of soil that is adequate to the plants used.

The aesthetic role is fulfilled only after the plants have reached maturity and the enveloped surface is perfectly covered by plants.

The vegetal envelope protects the exterior of the building and, due to the permeability of the materials used, the oxygen level is ensured to those who perform their activity inside the building. This is achieved through the processes of resuspension of dust and allergens in its composition (a process that prevents the emergence of allergies) and of absorption through the roots.

For the purpose of the present research, out of the three abovementioned options, a vertical garden (facade type) was opted for, due to the fact that it has lower costs than the other two, since its maintenance (near zero) and complexity levels proposed in the project are minimal.

The advantages of a vertical garden:

- One square meter covered with plants holds up to 130 g of dust and can produce the amount of oxygen needed by an individual over a year;
- The effect of the "heat island" present in urban agglomerations during the summer season is diminished until it becomes blurred;
- A medium-sized vertical garden (60 square meters) captures 40 tons of carbon in a year, thus being sufficient for six people, even under the current conditions for reducing the imprint associated with this chemical element;
- From a real-estate point of view, the value of the building increases because of the higher environmental benefits;
- The mental state of the employees in such a building is modified in a positive manner, due to its aesthetic impact, thus creating the premises for an increase in their efficiency;
- Its installation requires a short time;
- Not only is the air pollution reduced, but also the noise (up to 10 decibels);
- If species of lichens are used, they are not a suitable environment for the development of microorganisms and do not require maintenance efforts.

The construction of an urban garden

When it comes to the green space per capita, Bucharest ranks very low among the other European capitals. At the European Union level it has been decided that the optimal green space area per capita should be 26 square meters. At the national level, the data from the National Institute for Statistics indicate that a Romanian benefits from 21.4 square meters of green space. On the other hand, the World Health Organization considers the optimum to be of 50 squares meters per capita.

Taking all this into account, the prospect of developing an urban garden at a height, like in our case, on a large terrace of about 100 m^2, represents the way to adapt to modern times and the desire to evolve in an era of ruthless consumption and speed.

By involving public and private entities as well as volunteers in the project, its implementation can be done with minimal expenses, in such a manner that in the medium and long term it does not only improve the environment but also generates profit.

Plant seedlings (cauliflower, tomatoes, cucumbers, red beets) and aromatic plants will be grown. They can generate added value through processing (pickles) and can be used in the BUES canteens, where most of the community of about 23,000 people eat five days a week.

Additionally, the scraps obtained from the canteen can be used as compost, thus respecting a complete cycle of recycling and reuse. Water for drip irrigation will be collected from rainwater, and it will be directed to the garden with the help of the gravitational force.

The maintenance of the seedlings will be done in turns by groups of 5–10 volunteer students who are members of the ASEAM (Students' Association—AgriFood and Environmental Economics) NGO. The volunteer groups will provide daily care for 2 h, except during the summer when the periodicity is not as necessary. They will be regularly assisted by agriculture and horticulture teachers, engineers or other experts in this field, who will supervise their activity. The accounting, marketing, and advertising costs will be covered or even offered free of charge by the ASEAM alumni community (since these are their areas of specialization).

5. Discussion

The two projects presented above can be implemented in any academic community and in time they will both have a genuine environmental impact by generating a lower amount of carbon.

Such projects can also lead to improved sustainability thanks to the high level of productivity resulting from the good communication among all the individuals involved in volunteering projects in a micro academic environment.

The project costs are relatively low and they could be covered from either private or public funding.

In our case, the costs for building the vertical garden are of approximately 2760 euros, while those for the urban garden amount to about 9000 euros (to be spent over a three-year implementation period), as can be seen in Tables 1 and 2 below:

Table 1. The costs of building a 100 square meter green facade.

No.	Plant Name and Technical Materials	Unit Price EUR	Quantity (Items)	Total EUR
1.	Capsule with metric type thread/steel eye screw-8 × 43/12 × 215 mm	1.77	70	123.95
2.	Stainless steel spinodal cable, AISI 316	4.67	325 (meters)	1520.05
3.	Steel tensioner for tensioning	2.08	310	644.82
4.	Clamps for connecting cables	2.5	40	100
5.	Plants—lichens	72.5	1	72.5
6.	Manpower costs—assemblage	10% of the price of materials	1	246.23
	Planting in the soil	10.41	1	10.41
	Plants hanging	41.66	1	41.66
	Price per facade square meter			27.53
7.	TOTAL (EUR)			2760.66

Source: personal analysis of data collected from retail websites.

Table 2. The costs of building a 100 square meter urban garden.

Budget Category	Unit	Unit Price (EUR)	Quantity (Items)	Total Cost (EUR)
1. Human Resources (Project Team, Staff from the Financial Department Involved in Reporting, Collaborators)				
Coordinator GrădinASEAM (Students' Association—AgriFood and Environmental Economics)—Roxana Chiocaru	month			0
ASEAM Volunteers	month			0
Category Subtotal				0
2. Direct Project Costs (Services, Materials, Equipment, etc.)				
2.1 Design Services, Implementation, Maintenance, etc.				395.83
Backhoe Rental	day	166.66	2	1595.2
Backhoe Handling	day	31.25	2	62.5

Table 2. *Cont.*

Budget Category	Unit	Unit Price (EUR)	Quantity (Items)	Total Cost (EUR)
2.2 Materials/Equipment				6369.47
Vegetal Soil	m3	20.83	30	625
Compost	m3	104.16	1.3	135.41
Aromatic Plants	piece	3.12	72.3	225.93
Seed Varieties	sachet	2.08	20	41.66
Cauliflower Seedlings	piece	4.16	1.5	6.25
Cucumber Seedlings	piece	8.33	1	8.33
Red Sugar Beet Seedlings	piece	4.16	1.2	5
Red Seedlings	piece	20.83	1	20.83
Mulch Pedestrian Alleys	m3	52.08	6	312.5
Fruit Trees and Shrubs	piece	2.08	50	104.16
4 × 1 m High Layer Materials (Timber, Hollow Screw, Corner etc.)	piece	72.91	25	1822.91
Irrigation System (Programmer, ppr 32 Pipe, ppr 40 Pipe, Flexible Tube, Drip Tube, Sockets, Consumables)	system	1145.83	1	1145.83
Hand Tools (Shovel, Spade, Pickaxe, Shovel, Fork, Rake, Hand Scissors, Power Scissors, Saw)	piece	13.54	35	273.95
Soffits	piece	2.08	20	41.76
Wheelbarrow	piece	38.54	2	77.08
Solar	piece	833.33	1	833.33
Materials Needed for the Composting Area	piece	72.91	1	72.91
Storage for Materials	piece	416.66	1	416.66
2.3 Transportation				469.79
Material Transportation	piece	62.5	6	375
Fuel	l	15.62	6.5	94.79
2.4 Organization of Events (Services and Materials)				104.16
Event Organizing Materials (Tea, Water, Food etc.)	piece	5.20	20	104.16
Promotion and Communication Services (Activity provided free of charge by ASEAM volunteers)	piece	1	0	0
2.5 Promotion and Communication of Projects (Services and Materials)				125
Promotional Materials (Facebook Ads)	piece	6.25	20	125
Online Promotion (via the social networks groups of the universities in Bucharest and others in the country)	piece	1	0	0
2.6 Graphic and Design Services (Services and Materials)				666.66
Flyers, Posters, Banners, Explanatory Panels, Garden Signage—Design and Execution	piece	416.66	1	416.66
Flyers Distribution in BUES Campus—ASEAM Volunteers	piece	1	0	0
Photo-Video Documentation	piece	20.83	12	250
Category subtotal				8130.93
3. Administrative Costs—Maximum 10% of the Project Budget				
Protocol (water, tea, fruit, vegetables, food, etc., other required products during organized events, glasses)	piece	4.16	12	50
Office supplies	piece	41.66	1	41.66
Projector	piece	243.02	1	243.02
Photo-video camera	piece	416.54	1	416.54
Category subtotal				751.22
4. Other expenses				0
TOTAL (EUR)				8882.16

Source: personal calculation by example budget form "Creștem Grădinescu" [46].

For this type of project, the financing can be external, both from the public and the private sector, as follows:

A. The Environmental Fund

According to Romanian legislation (Law no. 105/2006), projects that provide for the reduction of noise pollution in the urban environment, the management and use of clean technologies (thus creating an environment conducive to the conservation of biodiversity), reducing the impact of pollution on air, water and soil and reducing greenhouse gases (i.e., including carbon released into the atmosphere) are eligible for funding of up to 100,000 euros.

B. Private funds

From the private sector, the support for such projects includes the financing through the project entitled "Creștem Grădinescu—finanţare pentru grădini şi ferme urbane" (maximum 130,000 euros).

The projects proposed in this paper meet the budget requirements set by both entities. However, the second financing option was selected because besides the financial support, the financing project team also provides coordination and assistance throughout the project (Table 2 [46]).

Civil involvement in these types of projects is essential, because the power of the example of some volunteer activities with an ecological character specific to a healthy lifestyle with a progressive perspective is much higher than that of motivational speeches.

Implementing such a project within the Bucharest University of Economic Studies is meant to support the practical aspect of education and to establish information and awareness-raising campaigns that combine practice with theory. Additionally, collaboration between the educational actors is also desired, both inside and outside the university. Access to local products will be greatly facilitated in this context, as BUES canteens can reduce their expenses in the medium and long term, and the community of this institution will enjoy local products.

The social and economic impact will consist of encouraging new segments of the agriculture and environment sectors to apply contemporary innovations, relying on the feeling of community.

Debt and fines (if any), interest or penalties, costs of leasing, renting, or awarding cash prizes are included in the ineligible expenses area.

For eligibility it is necessary to participate in teams of at least three people, thus encouraging collaboration rather than competitiveness.

The implementation of this project is intended to bring about a change in the perception of living in a European capital, often considered as crowded and suffocating. The increase of green spaces, of urban gardens and farms, psychologically supports the human connection with nature, minimizing the effect of "robotic life", establishing a new social architecture and ensuring that the environment is also included.

6. Conclusions

Reducing the carbon footprint in order to meet the optimal values of the sustainability standards can be done through small actions that are also economically effective and are not intended exclusively for a specific type of building. Implementing concrete actions in a university campus can be a new way of approaching the world today and it should become part of the students' education for achieving higher living standards and sustainability.

Opting for urban gardens or for vegetable envelopment brings many benefits to humanity, but it also restores the human–nature balance. The aspect of birds abandoning the urban environment or their early death must also be taken into account. This phenomenon is caused by birds colliding with the multitude of buildings, as they do not have the ability to perceive transparent surfaces, therefore producing another imbalance in the biodiversity, which can be reconciled through solutions like the ones proposed in this paper. They allow the comfort of life in the city for both humans and animals.

While a wall made of brick or covered with polystyrene (considered cancerous by researchers) favors the suspension of particles and microorganisms in the air, buildings enveloped in vegetation retain and recycle dust and carbon dioxide, thus giving an example of ecological regeneration.

On a large scale, if these proposals were adopted, not only would the aesthetics and the air in the building change, but also the perception of people about the workplace, the city and life, since nature induces a state of calm, relaxation and hope. On the other hand, a space dominated by concrete is perfect for generating anxiety.

Reorientation towards the traditional values, natural capital and local food leads to a healthy life. At the same time, this type of insulation offers an alternative recreational space through its texture and brightness.

Turning to renewable energy represents a step forward in the contemporary society, a step that ensures progress. The dispersal of the society and the individualization were the precursors of the Revolution of 1989, and the community spirit had to suffer. It can be saved by volunteering, especially as presented in this paper, which unites both the people in the academic community and those outside it. The Bucharest University of Economic Studies can again serve as an example for Romania from a perspective that shows thoughtfulness for the environment, students, teachers and life in general.

In conclusion, this paper has illustrated how easy it is to make a change with a minimal investment, provided there is dedication and interest. Our society needs to take action in this crucial moment when the resources and quality of life can still be saved. In the absence of a responsible attitude associated with this sensitive point in the history of society, the future generations will have to suffer since they will have no alternative option.

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Energy Poverty in European Union: Assessment Difficulties, Effects on the Quality of Life, Mitigation Measures. Some Evidences from Romania

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Abstract: The scope of this research is to explore the relations between energy poverty, quality of life and renewable energy. First, an analysis of concept evolution, economic and social implications and the difficulties in assessing energy poverty was conducted by analyzing the data from Eurostat regarding electricity prices for households and arrears on utility bills between 2009 and 2018 and the solutions for combating energy poverty from the EU. In the next part, a cross-country analysis regarding Granger causality between indicators representing all three dimensions was conducted. The period of the analysis was between 2010 and 2019 for the 28 EU member states. In the final part of the article, the situation of Romania was analyzed. The phenomenon of energy poverty is not marginal but is underestimated and superficially approached. Starting from the dominant discussions on the concepts and tools practiced at international level, this article makes a proposal for a working model for various regions in Romania, taking in consideration the financial potential of the geographic areas and the possibilities of accessing unconventional energies by local communities. Through a case study based on the analysis of relevant energy resource statistics, the article identifies main shortcomings and opportunities for Romania and proposes concrete recommendations of sustainable public policies on the elimination of energy poverty. In some geographic areas where this was not possible, we propose how to diminish the effects of this social phenomenon. Our proposals for the case study focus on supporting populations in areas where access to energy sources is difficult and there is a lack of energy infrastructure, the government programs being an alternative to access green (renewable) energies. Even if this may seem expensive to some specialists in the economy, access to energy sources of any kind brings social advantages by improving quality of life-in this case, a real victory in the fight against energy poverty.

Keywords: energy poverty; quality of life and renewable energy

1. Introduction

The launch of the Sustainable Development Goals (SDGs), by United Nations Organization, in 2015, demonstrated the importance of access to energy in order to ensure the quality of life for all the citizens. Compared to the Millennium Development Goals (MDGs) the new goals are more diversified, complex: through the links between them, sustainable development will be generated. Even the Millennium Development Goals advocated for reducing extreme poverty, improving living conditions and sustaining progress for sustainable development, no direct reference to access to energy was done [1,2]. This situation was remedied in 2015, the energy being the topic of a distinct goal, with many connections and with other objectives.

Goal 7-"Affordable and clean energy"-is one of the 17 objectives, but considering that energy accessibility has consequences on the quality of life and the environment, it may be said that energy is the core of SDGs. Access to energy ensures the guarantee of fundamental human rights, but also social-cultural rights such as the right to food, to a heated home, to education, to decent working conditions, to maintaining a healthy state consistent with age. Moreover, the idea of a fundamental right to energy, launched by the UN Secretary-General, Ban Ki-Moon, came up with the 2014 "Sustainable energy for All" Initiative. The energy problem has become more nuanced by launching the concept of clean energy or sustainable energy because the poor population is frequently in the situation of using polluting fuels, with negative effects on the health of the users and the environment [2–5]. The magnitude of this phenomenon worldwide and its consequences on the population are demonstrated by the statements of World Health Organization officials who have declared that energy poverty generates more deaths compared to malaria or tuberculosis [2]. In addition, indoor air pollution caused by the use of polluting fuels to heat the home and to prepare food favors the appearance of specific diseases, such as respiratory infections, which puts pressure on public health systems that are not very strong in developing countries anyway.

Therefore, energy has gained its proper place not only in scientific and political debates, but also in the concerns of researchers and public authorities. The energy-economic development relationship is analyzed bidirectionally. On one hand, economic development affects energy consumption. In the initial phases, energy consumption increases as production capacities develop. Later, growth of energy consumption is tempered as a result of more efficient use of the energy with the generation of technical progress. On the other hand, energy generates economic growth, being considered a factor of production [6–12]. Additionally, limited access to energy or reduced energy efficiency have negative effects on quality of life, environmental protection or economic growth. Energy dependence has economic, social and political consequences [13–15]. For this reason, renewable energy has gained importance, being seen as a tool for achieving the goals of sustainable development [16–18].

The scope of this research is to explore the relations between energy poverty, quality of life and renewable energy for EU countries and especially for Romania. The novelty of the scientific approach is given by the analysis of the statistical data for the period 2010–2019 and the measures proposed for the specific situation of Romania. The article is structured into several sections. In part one, we present the concept of energy poverty, and we pointed out that the evolution of the concept captured the specificities of developed countries, developing countries, warm areas and cold areas. Reducing and eliminating energy poverty is a goal of all public authorities, given the negative consequences that the phenomenon has on the welfare of the population. In the next section, an analysis of the difficulties in assessing energy poverty is conducted by analyzing data from Eurostat concerning electricity prices for households and arrears on utility bills between 2009 and 2018-and the solutions for combating energy poverty from the EU countries. After this, a cross-country analysis concerning Granger causality between indicators representing all three dimensions is conducted. In the final part of article, the situation of Romania is analyzed in order to propose concrete measures for mitigation of this phenomenon.

2. Energy Poverty and Quality of Life

The reduced accessibility to energy for certain categories of the population has generated international debates in various forums, but also the emergence of numerous concepts such as energy poverty, fuel poverty, vulnerable consumer/energy vulnerability, energy efficiency, energy richness (which involves not only meeting needs through proper access to energy, but energy efficiency) or establishing connections with other concepts such as social exclusion, energy culture [4,19], energy security, decarburization of the economy, energy transition, energy union [20]. The tools for ensuring the access to energy are multiple and the stakeholders involved have specific responsibilities. If the public authorities have the mission to create the specific legal and institutional framework, companies must develop technologies and products that ensure energy efficiency, adopt green and lean management strategies, the employees must acquire the specific competences to use the equipment, and the consumers must have responsibilities regarding the consumption of energy, home improvement conditions [21–25].

Energy poverty is defined as the inability of a person or household to meet the minimum energy needs [4] or the specific situation of a household that faces inadequate access to essential energy services [19], the situation being specify not only

- for the cold season, but also in the hot season, when energy is needed to operate the air conditioning equipment in order to reduce the temperature in the living spaces [26]; the problem became more stringent with the climate changes and the temperatures increase;
- countries in temperate and cold areas and also in hot areas, where the population needs energy for cooling purposes [27].

As expected, as in other fields of activity, there is no unanimity regarding the definition of the concept, indicators of measurement or political approach, not even within the European Union, which is why, at European level, the principle of subsidiarity is applied and the European Commission plays an important role in the coagulation process of European initiatives [5,26,28].

This situation is characterized by other specialists as the need for a household to spend disproportionately much of the income obtained on energy services [29]. The causes of this socio-economic complex phenomenon are numerous and are multiple interdependencies between them. The low level of income, rising energy prices as a result of reforms (privatization of companies with majority state owned capital) and liberalization of the energy sector, volatility of the international oil price, reduced efficiency of buildings and electrical appliances that are used in a household, a system of property ownership that does not encourage energy efficiency, specific to Central and Eastern European countries, energy needs also consumer behavior, age and consumer health [4,5,19,20].

Although the concepts of energy poverty and fuel poverty are sometimes considered synonymous, the idea that energy poverty is a broader concept has been prevailed in scientific literature [30]. This concept is used at EU level, in official documents like the Third Energy Package. The United Kingdom and Ireland have been among the first countries to have concerns regarding cold and inefficient homes, but later also the countries of Central and Eastern Europe, but also of Western Europe it was concerned about the problem of access to energy of the population, of the determined factors, of the economic and social consequences. The involvement of the EU in creating a transnational framework to address and solve this problem, the activity of international development organizations and researchers who have expanded their concerns and studies on countries in Africa, Asia and Latin America have generated a geographic diversity of specific aspects of energy access and consecration of energy poverty concept.

Researchers such as Bouzarovski & Herrero [31] even draw attention to the situation in Central and Eastern Europe, which it is considered one of the ’hotspots’ of energy poverty in the EU, with Bulgaria, Romania, Poland and Lithuania leading. The international financial crisis and the austerity measures adopted by all states have deepened the vulnerabilities of the population regarding access to energy [32]. In the countries of Africa, paradoxes are the order of the day. Countries, such as Nigeria, characterized by massive economic dependence on the oil and gas sector, are characterized by high demand for energy, acute energy poverty, inefficient energy use and inadequate supply.

Therefore, the ratio of the population to the energy poverty is different depending on the level of development of the country: in developing countries, a reduced access on a large scale to energy services is observed, while, in developed countries, difficulties in ensuring energy consumption according to needs could be identified.

The problem could be approached in a multidimensional way, considering the numerous consequences of energy poverty (or the inverse phenomenon, of energy wealth) on the quality of life or on the pollution of the environment. Studies from international literature [27,33,34] have drawn attention to the negative consequences of energy poverty on the health status of the population, the researchers observing an indirect relation between access to energy and winter mortality, heart and respiratory diseases. In addition, the consequences extend to the quality of life. Moreover, the predominant use of certain fuels, in developing countries, in households-wood, coal or material waste generates negative effects on the health status as a result of poor combustion, the non-ventilation of houses generating indoor air pollution characterized by the existence of high levels of carbon dioxide and suspended particles [2] in some cases, even larger than those specific to large cities for outdoor pollution.

Indoor pollution is a very serious phenomenon affecting mainly children and women. Statistical data from World Health Organization demonstrated that, indoor pollution doubles the risk of pneumonia and other acute infections for children under five years. The indoor pollution has long-term negative repercussions on health of adolescents and adults; This situation generates not only direct (medical), but also indirect (social) costs. At the EU level, treating asthma and other lung diseases involves costs of EUR 82 million. Raising the price of energy bills can generate a restructuring of family budgets, meaning that for the coverage of specific expenses, citizens can reduce their income for food to cover these expenses, which can have adverse effects on the health status.

Energy poverty mainly affects people in rural areas who, in order to meet the heating needs of homes and food, use different fuels or biofuels; in households, as a rule, women are responsible for providing these fuels. The lack of energy services offered on a commercial basis (absence of commercially supplied energy) generates, in these communities, an accentuation of the gender asymmetry of living conditions [35] limits the access to education, information and participation in political life [20]. Moreover, there are researchers who draw attention to fires generated by inadequate use of cooking or heating equipment [36]. Children are the most vulnerable segment of the population, given their low risk assessment capacity. Unfortunately, their involvement in fires has immediate repercussions on the state of health, but also long-term effects in the form of educational, psychological and social deficiencies.

The issue of energy poverty was initially addressed in the UK, which, together with Ireland, were the only countries in the EU that recognized and tried to solve this problem [37,38]. Subsequently, several countries became aware of this problem, and the fight against energy poverty has become an economic policy objective at national and European level, entering the concerns of many EU institutions. The EU Directives 2018/2002 and 2012/27 regarding energy efficiency consider the modeling of the energy demand and the improvement of the energy efficiency, one of the objectives being to reduce the energy poverty [39,40].

3. Assessment Difficulties

Within the EU borders, it is recommended that every member state suggests countermeasures to combat energy poverty. Obviously, these countermeasures have to be tailored in order to suit the national reality. Currently, Romania has gaps in correctly assessing the level of energy poverty. On the other hand, combating this phenomenon has proved being inefficient. The issue resides in the fact that both measuring the phenomenon and combating are limited to aspects regarding the level of household income, social tariffs implemented by providers and granting State supported benefit schemes to cover heating costs for a certain category of vulnerable consumers.

In Romania, there are 8.92 mil. homes and 7.494 mil. households [41] (In Romanian Census practices there is a difference between home and household. A home is an apartment or a house and a household consists of the individuals (persons) who live in that house or apartment (they may form a family or not). Hence, there can be more households in the same home, but also a household can own more homes). According to data from the [42–45], considering the European context and the specifics of Romanian economy and society, the issue of energy poverty can be summarized as follows:

- Approximately 3.75 million households in Romania use biomass, usually firewood, as the main heating source (about 90% in rural areas and 15% in urban areas), spending 10.50 EUR/month on average for this type of fuel.
- Less than half of Romania's households are connected to the natural gas network (44.2%) and around 2.97 million homes (i.e., a third of the total homes in the country) use natural gas directly as their source of heating.
- Although the end-price of natural gas and electric power is considerably lower in Romania than the European average, Romania has the lowest consumption level of electric energy per capita in the entire European Union-37.5% of the EU average (approximately 0.6 MW h/person/year than the EU28's average of 1.6 MW h/person/year). And this is although there are approximately 287,000 homes in Romania not yet connected to the grid.

In the past 10 years, electricity prices for households in Europe have been constantly on the rise. In EU28, the average price per kilowatt hour has risen from 0.24 EUR in the first half of 2009 to 0.39 EUR in the first half of 2019 (Eurostat), with obvious differences between states (Table 1). The highest prices are in Spain (0.65 EUR), Germany (0.49 EUR) and Belgium (0.47 EUR); the lowest prices in the EC are registered in Hungary (0.11 EUR), Lithuania (0.13 EUR) and Romania (0.13 EUR).

Table 1. Electricity prices for households.

	S1-2009	**S1-2010**	**S1-2011**	**S1-2012**	**S1-2013**	**S1-2014**	**S1-2015**	**S1-2016**	**S1-2017**	**S1-2018**	**S1-2019**
EU28	0.2487	0.2644	0.2725	0.2769	0.3011	0.3145	0.3252	0.3290	0.3398	0.3487	0.3948
BE	0.2628	0.2930	0.3034	0.2921	0.2907	0.2661	0.2641	0.4088	0.4988	0.4300	0.4742
BG	0.0844	0.0823	0.0840	0.0857	0.0957	0.0851	0.0969	0.0978	0.0977	0.1000	0.1014
CZ	0.2517	0.2612	0.2883	0.2915	0.2922	0.2587	0.2578	0.2670	0.2693	0.2878	0.3204
DK	0.2991	0.2973	0.3215	0.3308	0.3304	0.3325	0.3865	0.3843	0.3767	0.3838	0.3662
DE	0.3599	0.3664	0.3835	0.3917	0.4257	0.4329	0.4366	0.4555	0.4742	0.4731	0.4985
EE	0.0945	0.0995	0.1008	0.1143	0.1424	0.1347	0.1347	0.1247	0.1237	0.1537	0.1644
IE	0.4330	0.4034	0.4262	0.5466	0.6076	0.6475	0.6970	0.4091	0.4151	0.3842	0.3633
EL	0.1049	0.1175	0.1580	0.1818	0.2071	0.2302	0.2629	0.2642	0.2300	0.2303	0.2276
ES	0.3097	0.3870	0.3584	0.3418	0.3714	0.4760	0.5072	0.5215	0.5735	0.5952	0.6570
FR	0.2169	0.2276	0.2422	0.2411	0.2828	0.2678	0.2870	0.2821	0.3203	0.3468	0.3817
HR	0.2059	0.1896	0.1822	0.2229	0.2386	0.2286	0.2156	0.2266	0.2035	0.2176	0.2182
IT	0.2935	0.2833	0.2654	0.2571	0.2789	0.2935	0.2957	0.3135	0.3496	0.3063	0.5561
CY	0.1393	0.2120	0.2353	0.3180	0.3073	0.2638	0.2274	0.1860	0.2262	0.2976	0.3333
LV	0.1053	0.1050	0.1168	0.1171	0.1168	0.1164	0.1501	0.1614	0.1900	0.2270	0.2055
LT	0.1011	0.1212	0.1278	0.1315	0.1421	0.1367	0.1287	0.1261	0.1137	0.1121	0.1303
LU	0.2684	0.2454	0.2492	0.2492	0.2390	0.2357	0.2397	0.2328	0.2681	0.2913	0.3456
HU	0.1411	0.1973	0.1887	0.1693	0.1572	0.1369	0.1280	0.1262	0.1274	0.1182	0.1162
MT	0.2483	0.4235	0.4278	0.4385	0.4265	0.3882	0.3738	0.3522	0.4047	0.3677	0.3573
NL	-	-	-	-	-	-	-	-	−0.1168	−0.0260	0.0792
AT	0.2727	0.2538	0.2946	0.2978	0.3181	0.3175	0.3550	0.3695	0.3699	0.3652	0.3796
PL	0.1447	0.1729	0.1889	0.1797	0.1879	0.1845	0.1836	0.1602	0.1881	0.1724	0.1780
PT	0.3309	0.3379	0.3330	0.3914	0.3251	0.3989	0.3874	0.3819	0.3883	0.4077	0.3759
RO	0.0982	0.1039	0.1084	0.1085	0.1357	0.1334	0.1366	0.1302	0.1213	0.1332	0.1340
SI	0.2656	0.2610	0.2300	0.2212	0.2394	0.2527	0.2192	0.1865	0.2638	0.3395	0.3358
SK	0.2349	0.2246	0.2320	0.2563	0.2734	0.2389	0.2447	0.2154	0.2400	0.2460	0.2556
FI	0.2429	0.2505	0.2790	0.2851	0.2949	0.2967	0.3039	0.3091	0.3352	0.3446	0.3712
SE	0.2550	0.3443	0.3635	0.3524	0.3728	0.3554	0.3408	0.3642	0.3745	0.4057	0.4121
UK	0.1578	0.1470	0.1523	0.1821	0.2031	0.2404	0.2566	0.2480	0.2581	0.2720	0.3042
IS	-	-	-	0.2015	0.3111	0.3242	0.3302	0.3495	0.4048	0.3791	0.3409
LI	-	-	-	-	-	0.1541	0.1852	0.1729	0.1800	-	-
NO	0.3705	0.4573	0.4738	0.4567	0.4636	0.4124	0.4041	0.3729	0.3965	0.4144	0.4328
ME	-	-	0.1044	0.1247	0.2129	0.2260	0.2229	0.2065	0.1781	0.1819	0.1817
MK	-	-	-	-	0.0836	0.0812	0.0840	0.0829	0.0829	0.0802	0.0800
AL	-	-	0.1152	0.1163	0.1156	0.1156	0.0812	0.0824	0.0844	-	-
RS	-	-	-	-	0.2081	0.1646	0.1460	0.2420	0.2439	0.2568	0.2586
TR	0.1144	0.1341	0.1217	0.1329	0.1500	0.1194	0.1361	0.1266	0.1047	0.0916	0.0847
BA	-	-	-	0.2164	0.2270	0.2269	0.2447	0.2130	0.2224	0.2206	0.2090
XK	-	-	-	-	0.0804	0.0803	0.0914	0.0872	0.0941	0.0927	0.0789
MD	-	-	-	-	-	-	0.0794	0.0940	0.0942	0.0993	0.0912
UA	-	-	-	-	-	-	-	0.0249(p)	0.0393	0.0308	0.0339

Source of data: [42].

- Approximately 422,000 homes (i.e., 4.73% of total homes) have informal access to electrical power, which means these houses are built without building permits;
- On average, Romanian households spend around 20 EUR/month on power, and around 12 EUR/month on natural gas.
- Around 14% of Romania's population is unable to adequately heat their homes (UE average is 8.7%), and around 15% of households have difficulties paying electricity bills;
- Around one million households in Romania benefit from some form of social assistance: heating benefits (emergency ordinance 70/2011), respectively social tariffs for electricity (Order no. 176/20,154 of NAER);
- Heating benefits (covering only approximately 5% of the population) are the only social benefits not included in the national information system. Over 50% of the amount of heating benefits cover heating with firewood; support for heating with electricity has a weight of only 2% of the total (i.e., approximately 8000 households). In addition, 56% of the granted benefit goes towards the poorest 20% of the households. Although almost a quarter of the benefits is directed towards the poorest households, with an income of up to 155 RON (approximately 32 EUR) per family member, data reveals that approximately 70% of the households with this income do not receive any benefit;
- Twelve percent of Romania's population benefits from social tariffs, but 42% of the households applying for this tariff do not correctly dimension their consumption and exceed the minimum consumption threshold provided by law; consequently, the tariffs in their case are above the social level
- According to the EU's Observer of Energy Poverty, the main indicators for identifying energy poverty are low absolute energy expenditure, arrears on utility bills, high share of energy expenditure in income and the inability to keep the home adequately warm. A series of secondary indicators can be added, the European Commission recommend list with 180 indicators which are adapted to specific regional/local coordinates.

A relevant indicator of energy poverty (regardless of whether) reflecting poor access to energy or fuel poverty) in low-income countries with high poverty rates is 'arrears on utility bills', which can reveal the rate of households inability to pay utility bills (heating, electricity, natural gas, water, etc.) on time, due to low purchasing power and/or high prices. In EU-28, the average for these types of situations decreased from 9.1% to 6.6% between 2010 and 2018, with major differences between countries (Table 2). In 2018, 36.9% of the inhabitants of North Macedonia, 35.6% of Greeks, 30.1% of Bulgarians and 17.5% of Croatians registered delays in the payment of energy bills. Above the Eurozone average of 6%, there are countries like Romania (14.4%), Slovenia (12.5%), Hungary (11.1%), Cyprus (12.2%), as well as Spain (7.2%) and France (6.4%).

- There is a 'hidden' energy poverty represented by households with very low energy bills expenditures because they limit their consumption partially, or almost totally. M/2 is used to estimate this type of energy poverty. The M/2 indicator indicates the share of households whose absolute energy expenditure is below half of the national median (the median of absolute energy expenses of households).

Table 2. Arrears on utility bills (%)-EU-SILC survey.

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
European Union-27 countries (from 2020)	-	9.6	9.6	10.1	10.4	10.3	9.4	8.4	7.3	6.8
European Union-28 countries (2013–2020)	-	9.1	9.0	9.9	10.2	9.9	9.1	8.1	7.0	6.6
European Union-27 countries (2007–2013)	8.9	9.0	8.9	9.8	10.0	9.8	8.9	7.9	6.9	6.5
Euro area (EA11-1999, EA12-2001, EA13-2007, EA15-2008, EA16-2009, EA17-2011, EA18-2014, EA19-2015)	-	-	7.4	7.7	8.0	8.5	8.4	7.3	6.1	6.0
Euro area-19 countries (from 2015)	7.3	7.4	7.5	7.9	8.1	8.6	8.4	7.3	6.1	6.0
Euro area-18 countries (2014)	7.2	7.4	7.5	7.8	8.1	8.5	8.4	7.2	6.1	5.9
Belgium	5.9	5.8	6.0	6.1	5.0	5.8	5.1	5.0	4.0	4.5
Bulgaria	32.1	31.6	28.6	28.4	34.0	32.9	31.4	31.7	31.1	30.1
Czech Republic	4.0	4.2	4.3	4.1	4.0	4.7	3.0	3.0	2.1	2.1
Denmark	2.6	3.2	3.4	3.5	3.6	4.6	3.4	2.5	3.5	5.1
Germany (until 1990 former territory of the FRG)	3.6	3.5	3.9	3.4	3.6	4.2	4.0	3.0	2.8	3.0
Estonia	10.0	11.0	11.8	10.9	10.4	10.0	7.9	7.9	6.3	6.5
Ireland	11.2	12.6	14.8	17.4	17.9	18.2	15.2	11.9	9.9	8.6
Greece	18.9	18.8	23.3	31.8	35.2	37.3	42.0	42.2	38.5	35.6
Spain	6.3	7.5	5.7	7.5	8.3	9.2	8.8	7.8	7.4	7.2
France	7.5	7.1	7.1	6.7	6.2	6.3	5.9	6.1	6.1	6.4
Croatia	-	28.0	27.5	28.9	30.4	29.1	28.7	25.3	21.0	17.5
Italy	11.3	11.2	12.0	11.7	11.9	12.2	12.6	8.9	4.8	4.5
Cyprus	13.3	16.3	16.9	18.4	21.9	20.5	20.1	15.4	13.7	12.2
Latvia	17.8	22.5	23.4	22.4	20.7	19.6	16.7	13.2	11.9	11.6
Lithuania	8.4	10.9	11.8	12.6	13.2	10.4	8.4	9.7	7.9	9.2
Luxembourg	2.3	2.1	2.2	2.2	3.1	3.2	2.4	4.0	1.7	3.6
Hungary	20.7	22.1	22.7	24.4	25.0	22.3	19.4	16.2	13.9	11.1
Malta	7.9	6.8	8.6	10.1	11.6	14.6	10.2	9.5	5.6	6.9
The Netherlands	2.1	2.1	2.4	2.3	2.4	3.0	2.7	2.0	2.1	1.5
Austria	4.0	4.4	4.0	3.8	4.6	3.5	3.5	4.2	3.6	2.4
Poland	12.5	13.9	12.9	14.1	14.0	14.4	9.2	9.5	8.5	6.3
Portugal	6.1	6.4	6.7	6.3	8.2	8.5	7.8	7.3	5.6	4.5
Romania	25.1	26.5	27.3	29.7	29.7	21.5	17.4	18.0	15.9	14.4
Slovenia	16.9	18.0	17.3	19.3	19.7	20.3	17.5	15.9	14.3	12.5
Slovakia	11.3	9.6	6.4	5.8	5.9	6.1	5.7	5.7	5.5	7.9
Finland	7.5	6.9	7.8	7.9	8.4	7.9	7.5	7.7	7.8	7.7
Sweden	5.4	5.2	4.6	4.3	4.7	3.6	3.2	2.6	2.2	2.2
United Kingdom	-	5.6	5.0	8.9	8.7	7.2	7.0	5.7	5.0	5.4
Iceland	3.9	7.0	7.5	7.0	7.5	7.5	6.6	6.0	-	-
Norway	6.5	6.3	6.9	4.6	4.5	3.1	3.2	2.4	3.0	2.7
Switzerland	5.6	4.8	3.5	3.6	3.0	4.2	3.6	4.5	3.6	4.1
Montenegro	-	-	-	-	37.3	52.3	38.4	34.8	31.6	-
North Macedonia	-	39.3	36.2	38.9	39.6	38.8	40.1	41.0	38.6	36.9
Serbia	-	-	-	-	36.7	41.4	34.8	34.8	18.1	28.4
Turkey	39.7	-	44.0	41.8	39.8	35.8	33.2	29.0	26.3	-

Source of data: [42].

4. Micro-Solutions for Combating Energy Poverty. Examples of Good Practices in Europe

In countries such as Spain, Germany, Belgium and the UK, there is a successful practice of countering energy poverty by counseling vulnerable families who encounter difficulties in paying their utility bills [46–52]. These solutions are less costly (falling into the category of non-financial measures), partly rely on volunteers and are applicable at the local community level in any European country. Some different projects-with various stakeholders, different financial implications and structures of implementation-aimed at reducing energy poverty and improving household resilience to energy needs, are presented below.

4.1. Spain-The Ni un Hogar Sin Energia (No Home without Energy) Project

In Spain, about seven million people are affected by arrears on utility bills and/or experience abnormal temperatures in their homes [46]. Such a situation affects quality of life by detrimental effects on health, children's education and personal savings. In this context, a non-governmental organization has initiated a project to assist the people who do not understand the content of the bills and do not know how to act in order to reduce costs while also ensuring a comfortable temperate inside the house. The program's objectives are to make recommendations to people about adjusting the electricity supply contracts, to propose measures in order to increase the energy efficiency by thermal rehabilitation works on residential buildings or changing the consumption habits [47]. From 2013 to date, the foundation's assistants (social workers) have visited over 2000 households in over 30 Spanish cities and drew up a personalized energy diagnosis for each of them. Additionally, the foundation used the gathered data in order to build an on line platform, so that advice and knowledge were made available for over 4400 Spanish households to date, resulting in savings of about 125 EUR/household/year on average, hence a total of about 550,000 EUR/year [48].

4.2. UK-The Plymouth Energy Community Initiative

In Plymouth, over 1500 natural persons, economic operators and non-profits teamed up to establish a social enterprise with the purpose of rendering the energy production, purchase and use more efficient. The Plymouth Energy Community Initiative addresses both natural person's residents and local authorities, public institutions and economic organizations. The project is not limited to offer only advice in view of increasing energy efficiency and decreasing costs, but also to elaborate an investment scheme in which every participant (above the age of 16) can buy social shares with values between 50 and 100,000 pounds, under the motto: ˝People care more about things that they own˝. The shareholders become members of the Plymouth Energy Community, they can be a part of the organization's board and will collect an interest of 6% of the invested capital. The organization invests the amounts collected from selling social shares into the installation of solar panels on schools, public buildings or brownfield sites and for building community-led housing. These installations help the host building to reduce its energy consumption and the extra revenue is transferred to Plymouth Energy Community. Thus, a business model was created that helps citizens benefit from energy from renewable sources at reduced costs, the investors collect interest (usually above market level), and, additionally, more financial resources are created to generate new projects for reducing carbon emissions and energy poverty [49].

4.3. Belgium-The Papillon Project

The project implemented in the Flemish region of Westhoek in Belgium is a partnership between a company producing electric appliances and the local authorities. The project started from the following premises: one in three consumers affected by energy poverty owns energy inefficient household appliances that consume three to five times more than new ones; most consumers stricken by energy poverty cannot afford purchasing new appliances [50]. The project focuses on 100 households and offers them the possibility to rent new appliances for a fee of seven EUR/month. It includes ten types of household appliances; the rental fee covers installation, maintenance and warranty for a period of 10 years. The leasing fee is paid once per year by the social enterprise (Samenlevingsopbouw West-Vlaanderen, which is owned by the local authority) to the supplier of electric appliances, who remains the legal owner. After the contract expires, the appliances are returned to the supplier for reuse or recycling. The project is part of a broader implementation strategy of a circular economy, and is based on the following cost/benefit synthesis (Table 3)

Table 3. The Papillon Project, cost/benefit synthesis.

	The Classic Model	The Papillon Model
Energy consumption	591 kWh	204 kWh
Energy cost 10 years (0,36 €/kWh)	2128 €	735 €
Repair	300 €	included
Provision new appliance	500 €	-
Rental fee	-	694 €
Total cost	2928 €	1429 €

Source: [51].

4.4. Germany-The Program for the Reduction of Interruptions in Electricity Supply

Even in Europe's most powerful economy, Germany, there were 370,000 cases of disconnection from gas and power networks in 2017 alone. Implemented in the German state of North Rhine-Westfalia (in the fief of the Rhenish model of social market economy), the program includes energy suppliers, local authorities, institutions of social protection, but also non-governmental organizations. The program carries various activities such as offering advice to vulnerable consumers as well as providing legal representation in their relationship with energy suppliers and associated services, organizing debates, lobbying for domestic consumers, but also a series of other public relations activities. To date, the program was successful in offering legal and technical advice to a number of over 15,000 consumers, in preventing disconnection from the network for 80% of the households that benefited from advice and representation, in obtaining the revocation of over 60% of the already operated disconnections, and, ultimately, in raising public awareness about the fuel poverty issue [52].

5. Cross-Country Analysis

In this part, a cross-country analysis regarding Granger causality between indicators representing all three dimensions was conducted. This is needed to see if there is a connection between indicators of the three dimensions, quality of life, energy poverty and renewables. The study starts from the hypothesis that there is a Granger causality between all selected variables. If one or more relations are found the number of indicators will be expanded in a future research in order to create a better connection chart between the three dimensions indicators. The selected indicators are the main used in each of the three dimensions. The period of the analysis is between 2010–2019 for the 28 EU member states. The indicators included in the analysis are:

- ➢ electricity prices for households, medium size, EUR/Kwh, (PR);
- ➢ inability to keep the home adequately warm,%, (WARM);
- ➢ arrears on utility bills between,%, (ARR);
- ➢ gross domestic product, million EUR, (GDP);
- ➢ share of renewable energy in gross final energy consumption,%, (RENEW).

In order to avoid autocorrelation, the data series were investigated for unit root using Levin, Lin & Chu t*, Im, Pesaran and Shin W-stat, ADF-Fisher chi-squared, PP-Fisher chi-squared tests. For unit root tests, we used Schwarz info criterion, Newey-West automatic band width selection and Bartlett kernel.

To test causality relations between the variables, we started from the Granger (1969) hypothesis [53] that tested how much of the variable y may be deduced from the past values of x, and then asked if that, by adding the past values of x, we can obtain a better approximation of y. A variable y is Granger-caused by x when x improves the predictive capacity of y or when the past coefficients of variable x are statistically significant. It must be acknowledged that a two-way causality is a frequent case when x Granger causes y, and y Granger causes x.

In order to apply a Granger causality test, a Lag length 1 must be specified. Usually it is better to use more lags in order to get relevant information from the past. In our study, we tested the Granger causality relation between the variables for 1, 2 and 4.

After establishing the lag length, we estimated a bivariate regression of the form:

$$y_t = \alpha_0 + \alpha_1 y_{t+1} + \ldots + \alpha_l y_{t-l} + \beta_1 x_{t+1} + \ldots + \beta_l x_{t-l} + \varepsilon_t \tag{1}$$

$$x_t = \alpha_0 + \alpha_1 x_{t+1} + \ldots + \alpha_l x_{t-l} + \beta_1 y_{t+1} + \ldots + \beta_l y_{t-l} + \mu_t \tag{2}$$

for each possible pair of (x,y) series of the group. F-statistic reported values were the Wald statistics for the consolidated hypotheses:

$$\beta_1 = \beta_2 = \ldots = \beta_1 = 0 \tag{3}$$

For each equation, the null hypothesis was that x did not Granger-cause y in the first regression and y does not Granger-cause x in the second regression.

In order to estimate the regression equation, it was started from the linear regression using the OLS method with panel data of the form:

$$Y_{it} = f(X_{it}, \beta) + \delta_i + \gamma_t + \epsilon_{it} \tag{4}$$

This specific case implies a conditional mean linear specification so that we achieve:

$$Y_{it} = \alpha + X'_{it}\beta + \delta_i + \gamma_t + \epsilon_{it} \tag{5}$$

where Y_{it} is the dependent variable, X_{it} is a regression vector k and ϵ_{it} error terms for i = 1, 2, . . . , M transversal units, observed for the dated periods t = 1, 2, . . . , T. α is the general constant of the model while δ_i and γ_t represents the effects specific to transversal section or time period.

As Engle and Granger [54] pointed out that a linear combination of two or more non-stationary series may be stationary. If this happens the non-stationary series are said to be co-integrated. The test for co-integration Kao test [55] it was used because it is suited for panel data. In Table 4 results of the testing for unit root are presented for all variable included in the analysis.

Table 4. Unit root tests.

Variable	Method	Level			1st Difference		
		Statistic	Prob	Obs	Statistic	Prob	Obs
ARR	Levin, Lin & Chu	−1.13972	0.1272	199	−6.23052	0.0000	171
	Im, Pesaran and Shin W-stat	0.85448	0.8036	199	−1.52648	0.0634	171
	ADF-Fisher chi-squared	50.7773	0.6723	199	77.4935	0.0302	171
	PP-Fisher chi-squared	51.2924	0.6534	227	140.190	0.0000	199
GDP	Levin, Lin & Chu	10.3967	1.0000	222	−10.1537	0.0000	194
	Im, Pesaran and Shin W-stat	9.54792	1.0000	222	−1.33694	0.0906	194
	ADF-Fisher chi-squared	12.8363	1.0000	222	74.6374	0.0487	194
	PP-Fisher chi-squared	20.7650	1.0000	250	69.7879	0.1019	222
PR	Levin, Lin & Chu	−9.87802	0.0000	224	-	-	-
	Im, Pesaran and Shin W-stat	−3.51807	0.0002	224	-	-	-
	ADF-Fisher chi-squared	111.535	0.0000	224	-	-	-
	PP-Fisher chi-squared	110.542	0.0000	252	-	-	-
RENEW	Levin, Lin & Chu	−8.19314	0.0000	196	−6.47698	0.0000	168
	Im, Pesaran and Shin W-stat	−0.70777	0.2395	196	−2.08310	0.0186	168
	ADF-Fisher chi-squared	82.1251	0.0130	196	85.0848	0.0073	168
	PP-Fisher chi-squared	74.6963	0.0482	224	130.768	0.0000	196
WARM	Levin, Lin & Chu	−0.79261	0.2140	202	−83.8692	0.0000	174
	Im, Pesaran and Shin W-stat	1.58888	0.9440	202	−8.78641	0.0000	174
	ADF-Fisher chi-squared	42.0318	0.9169	202	87.8995	0.0041	174
	PP-Fisher chi-squared	50.3423	0.6880	230	187.726	0.0000	202

Source: authors calculation based on data from Eurostat.

After testing for the unit root, it can be observed that electricity prices for households (PR) was the only variable that did not have a unit root at level, while the inability to keep the home adequately warm (WARM), arrears on utility bills between (ARR), gross domestic product (GDP) and share of renewable energy in gross final energy consumption (RENEW) had a unit root at level, but they became stationary at the first difference. In this case the decision was to take all variables at the first difference.

Before analyzing the Granger pairwise causality tests results, the correlation matrix should be inspected for the analyzed variables. In Table 5, the correlation matrix is presented.

Table 5. Correlation matrix.

	ARR	GDP	PR	RENEW	WARM
ARR	-	−0.756816	0.026646	−0.542304	0.958573
GDP		-	0.597827	0.954403	−0.882561
PR			-	0.776807	−0.174426
RENEW				-	−0.727907
WARM					-

Source: authors calculation based on data from Eurostat.

As can be seen from the correlation matrix, there was a very strong positive correlation between gross domestic product (GDP) and share of renewable energy in gross final energy consumption (RENEW), and a strong negative correlation with the inability to keep the home adequately warm (WARM). This was expected as the renewable energy sources are most explored by high income countries and higher share of inability to keep warm can be observed in lower income countries. The level of arrears on utility bills between (ARR) has a very strong positive correlation with inability to keep the home adequately warm (WARM), a strong negative correlation with gross domestic product (GDP), a moderate negative correlation with share of renewable energy in gross final energy consumption (RENEW) and no correlation with electricity prices for households (PR). Electricity prices for households (PR) had a strong positive correlation with share of renewable energy in gross final energy consumption (RENEW) and very low negative correlation with the ability to keep the home adequately warm (WARM).

Although the correlation between variables can be observed, there is no way to know, at this stage, if there is a causality relation between the variables or if a different variable has a result-determining influence on both. To see if there is a causality link, the pairwise Granger causality test must be used.

Next, in Table 6, there are the results of the pairwise Granger causality test. To have a better understanding of the causality relation in time between variables, it was tested for Lag 1, 2 and 4.

After analyzing the results of the pairwise Granger causality tests, several causality links were found. Arrears on utility bills between (ARR) Granger-caused gross domestic product (GDP) with a significance of 10% at Lag 4, but not at Lag 1 and 2, and that electricity prices for households (PR) Granger-caused arrears on utility bills between (ARR), with a significance of 5% at Lag 1 and 4, but not 2, which means that there was a short-term shock of electricity price and a long-term influence. The inability to keep the home adequately warm (WARM) Granger-caused arrears on utility bills between (ARR) with a significance level of 1% for all three lag lengths examined. This result was expected as low-income households would accumulate arrears on utility for keeping warm, but not at a comfortable level.

Gross domestic product (GDP) Granger-caused electricity prices for households (PR) at a significance level of 5% for Lag4, but not for Lag 1 and 2. Hence, the level of GDP generated and influenced electricity prices after four periods. Electricity prices for households (PR) Granger-caused the inability to keep the home adequately warm (WARM) with a significance level of 5% for Lag 1, but not for 2 and 4, so the shock of price increase will be absorbed in first lag and will not create future influences as households adapt to it.

Table 6. Pairwise Granger causality test.

Null Hypothesis: X Does Not Granger Cause Y	Obs	Lag1 F-Statistic	Prob.	Obs	Lag2 F-Statistic	Prob.	Obs	Lag 4 F-Statistic	Prob.
GDP → ARR	199	0.65741	0.4185	171	0.12821	0.8798	115	0.63582	0.6381
ARR → GDP		0.70168	0.4032		0.81076	0.4463		2.05587	**0.0918**
PR → ARR	199	4.50500	**0.0351**	171	2.27040	0.1065	115	2.91410	**0.0248**
ARR → PR		0.00374	0.9513		0.26519	0.7674		0.50699	0.7307
RENEW → ARR	196	0.85506	0.3563	168	2.08921	0.1271	112	1.30609	0.2727
ARR → RENEW		1.88433	0.1714		0.10233	0.9028		0.32235	0.8624
WARM → ARR	199	10.7082	0.0013	171	14.4907	0.000002	115	3.54172	0.0094
ARR → WARM		2.07083	0.1517		0.01139	0.9887		0.92337	0.4533
PR → GDP	222	0.16866	0.6817	194	0.02139	0.9788	138	0.16035	0.9580
GDP → PR		0.04526	0.8317		0.06253	0.9394		2.50856	**0.0451**
RENEW → GDP	196	0.18214	0.6700	168	0.51432	0.5989	112	0.68400	0.6046
GDP → RENEW		0.00550	0.9409		0.06587	0.9363		0.60201	0.6620
WARM → GDP	202	0.08995	0.7645	174	0.52699	0.5913	118	0.59411	0.6676
GDP → WARM		0.03966	0.8423		0.03294	0.9676		0.15206	0.9617
RENEW → PR	196	0.09995	0.7522	168	2.44530	**0.0899**	112	0.31634	0.8665
PR → RENEW		6.85317	0.0096		2.07078	0.1294		0.74513	0.5634
WARM → PR	202	0.05949	0.8075	174	0.04344	0.9575	118	1.75279	0.1437
PR → WARM		4.07290	**0.0449**		0.88235	0.4157		1.69942	0.1553
WARM → RENEW	196	0.90347	0.3430	168	1.69796	0.1863	112	0.69011	0.6004
RENEW → WARM		0.97074	0.3257		0.39134	0.6768		1.17125	0.3279

1% significance level, **5% significance level**, **10% significance level**; source: authors calculation based on data from Eurostat.

All relations presented until now are unidirectional and the only bidirectional relation was found between electricity prices for households (PR) and share of renewable energy in gross final energy consumption (RENEW) as PR Granger-caused RENEW with a significance level of 1% at Lag 1, but not on leg 2 and 4. RENEW Granger-caused PR with a significance level of 10% at Lag 2, but not on leg 1 and 4. Even though the causality relation is bidirectional this manifested at different lag lengths, and at different levels of significance. An increase of electricity prices could spike new investments in renewables at first lag, but the influence of renewables on electricity prices takes 2 lags and has lower probability.

Next the cointegration test is realized using Kao residual cointegration test for the analyzed variables presented in Table 7. In the test there were included 280 observations with no deterministic trend, lag-length selection based on SIC, Newey-West fixed bandwidth and Bartlett kernel.

Table 7. Kao residual co-integration test.

Kao Residual Co-Integration Test				
			t-Statistic	**Prob.**
ADF			−4.820553	0.0000
Residual variance			4.219468	-
HAC variance			1.937356	-
Augmented Dickey-Fuller Test Equation				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
RESID(-1)	−0.950714	0.071779	−13.24495	0.0000
R-squared	0.473336	Mean dependent var		−0.045481
Adjusted R-squared	0.473336	S.D. dependent var		2.106597
S.E. of regression	1.528791	Akaike info criteria		3.691921
Sum squared resid.	455.7545	Schwarz criterion		3.708646
Log likelihood	−360.8082	Hannan-Quinn criteria		3.698692
Durbin-Watson stat	2.076981			

Source: authors calculation based on data from Eurostat.

In addition, there are presented the results for ADF test equation on residuals using least square method with 1986 observations after adjustment.

6. Subsidies-Sustainability's Motor in the Tackle Energy Poverty?

In the last part of the study, an analysis of Romania's renewable sources potential was conducted also a comparison with the income data for each county.

Many experts believe that renewable energy is a solution that could solve the problem of energy poverty despite the challenges and limitations of using this energy source. Even if the generation of such an energy involves in some cases, higher costs than the production of traditional one, specialists emphasize the short-term and long-term benefits that its use induces. The implementation of renewable energy projects does not generate only disputes related to costs and investment financing, but also to their acceptance by local communities (given the negative externalities generated-like aesthetics, noise, biodiversity degradation, etc.). However, the renewable energy production projects could be a solution for the development of rural communities, which, in this way, providing the necessary energy, attracting the local labor force, thus ensuring the increase of the incomes of the local population [56–64].

Taking into account the current context regarding the access, in general of the European Union's population and in particular of Romania's people, to the energy sources for the creation of the minimum comfort in the households, it will be tried to define a model, for the future period which starts from the idea that, by implementing it, it will be able to lead to an improvement in the standard of living of vulnerable consumers affected by energy poverty.

The hypotheses from which it will be started the study are the following:

➢ The proposed model is addressed to the governmental factors of analysis and decisions, at the level of the Ministry of Energy;
➢ It is desired that all citizens have access to at least one of the green energy sources;
➢ It is required, according to the provisions of the European norms, the reduction of the greenhouse gas emissions by 20% compared to the level of 1990;
➢ In addition, in accordance with the European provisions, it is desired to increase to 20% the share of renewable energy sources in the final energy consumption;
➢ In the same context it is desired to reduce by 20% the primary energy consumption by improving the energy efficiency.

The most widely accepted indicators in practice and literature with a view to sizing the energy poverty phenomenon and targeting measures in order to combat it, consider a ratio between population incomes and household energy expenditure. In Romania, the only criterion used is the income per household, which leads to an incomplete understanding of the phenomenon. In the next lines of the article it will be presented an analysis of the statistical data, regarding the income of the population, for all the counties of the country.

Botosani, Vaslui, Calarasi and Giurgiu counties represent the extreme poles, with the lowest purchasing power. It follows in the ranking Suceava, Neamt, Vrancea, Buzau, Ialomita, Teleorman, Olt and Mehedinti a short distance from the first. The group of counties with purchasing power below the national average is completed by Satu-Mare, Maramures, Bistrita-Nasaud, Harghita, Covasna, Bacau, Iasi, Braila, Tulcea, Valcea, Dolj, Caras-Severin, Gorj, Salaj, Mures.

The counties located near the average in the country from the point of view of purchasing power are those that include cities in the development competition: Prahova, Arges, Constanta, Alba and Arad. In these counties, significant economic growths are foreshadowed, they serve as satellites of the big economic centers and benefit from the investments of the players who relocate their activities in the proximity of the big economic centers that become inadequate (Cluj, Timisoara and Brasov). All these cities occupy top places in the absorption of European funds and in the development of infrastructure. Arad has provided a large number of transport connections with the European road network, while Alba Iulia is the absolute national leader among the smart cities in the country, with most of the smart city projects implemented. The group of counties with high purchasing power begins with Brasov and Sibiu, "stars" on the map of the economic development of the country and the engines of the central area of Romania. For several years here, a new industrial area of the country has been configured, attracting massive investments.

Brasov County has developed on several market segments, mainly on real estate and Business Service, due to the number of people with technical skills and language skills, the central geographic positioning, and the lower costs compared to other localities and the very good living conditions. At the same time, the county owns the most industrial parks in the country (10), after Prahova (15) and Cluj (11), and the development of the automotive and retail industry also generated an explosion of residential constructions. Thus, in 2017 was completed the largest number of homes in residential complexes in the post December '98 history of Brasov.

Sibiu County, in turn, has become a magnet for investors coming to Romania, being attractive to the auto and IT industry. The largest industrial employer in the county and the giant in the automotive industry-Continental-expanded its investment in 2018, followed by other big players (Kika Automation) who transfer their activities to this region.

Counties such as Cluj, Timis and Ilfov, in front of Bucharest are the traditional poles of development of the country (red areas) where the purchasing power is at least 20% above the country average. These areas keep their development rates stable and have the quality of "diffusers" of investments for the neighboring areas, making them positive corrections.

In general, the reasons for developing cities outside Bucharest are related to the cheap and educated workforce. The industries that have found the best opportunities in such cities are the automotive, IT and Business Service industries. Another important factor is the transport infrastructure.

According to GfK [65], it is estimated that Sibiu, Brasov, Arad, Constanta and Alba Iulia are the cities that will soon see a greater development than Bucharest, precisely because they have a good infrastructure, but also university centers that will form the workforce market (Figure 1). Last, but not least, another factor that changes the map of local development is the dynamics of costs-the classic development areas become expensive for new investors (the case of Cluj which has the most expensive industrial land in 2019 in the country), and this causes them to orient to less explored areas of the country.

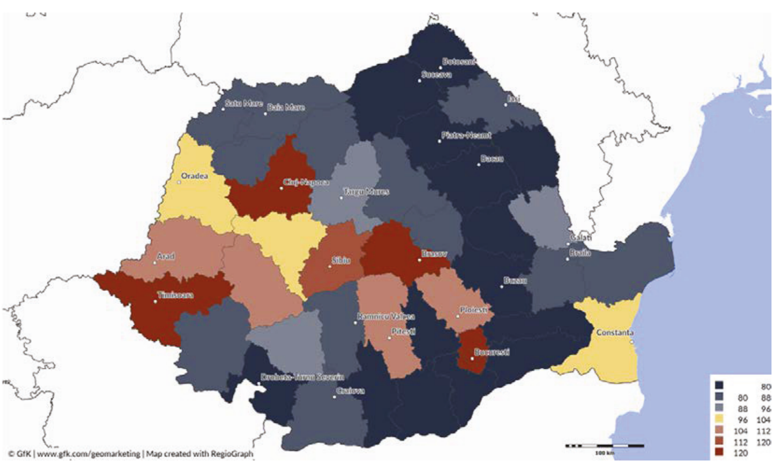

Figure 1. The purchasing power in Romania-2019; Source [66].

In addition, the regional competition intensifies with the availability of European funds. In this regard, some counties have adopted strategies and alliances to boost the attractiveness of these funds to develop their infrastructure-as is the case of the "Western Alliance", an alliance between four counties (Cluj, Timis, Arad and Oradea)-meant to boost the attractiveness of financing, for regional development.

Solar energy is considered as a renewable energy source, as it is energy emitted by the sun. Solar energy can be used for generating electricity through solar cells (photovoltaics) or through solar thermal power stations (heliocentric); heating buildings directly or through heat pumps; heating buildings and produce hot water for consumption through solar thermal panels [65].

In order to increase sustainability and viability of the model, the proposal for government's factors was subsidization purchasing of solar panel systems for households in counties that have-according to the map of the sun-the benefits of this type of energy. For example, the counties that can benefit from such subsidies for solar panels are Prahova, Buzau, Ialomita, Olt, Dolj, Constanta, Calarasi, Giurgiu and Arges.

Romania is in an area with a good solar potential of 210 sunny days per year and an annual solar energy flow between 1000 kWh/m^2/year and 1300 kWh/m^2/year. From this total amount it is possible about 600 to 800 kWh/m^2/year. The most important solar regions of Romania (Figure 2) are the Black Sea coast, Dobrogea de Nord and Oltenia, with an average of 1600 kWh/m^2/year.

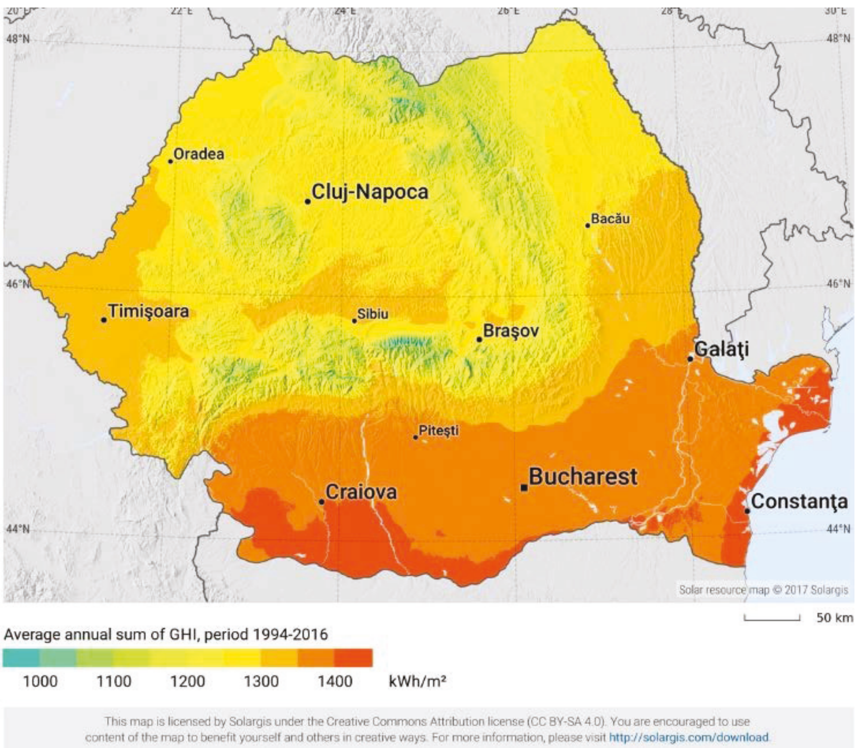

Figure 2. Map of sunshine in Romania (average between1994–2016). Source [67] https://www.fabricadecercetare.ro/regenerabil/.

Between the 1970s and 1980s, Romania was an important player in the solar energy industry, installing around 800,000 m^2 (8,600,000 ft^2) of low-quality solar panels, which placed the country in third place worldwide for total photovoltaic cell surface area. One of the most important solar projects was the installation of a 30 kW solar panel on the roof of the Polytechnic University of Bucharest, capable of producing 60 MWh of electricity per year.

Geothermal energy is energy stored in the form of heat beneath the solid layer of the earth's surface. The two fields of exploitation of geothermal energy are:

(i) Up to 500 m representing surface geothermal;
(ii) Over 500 m representing geothermal depth.

Referring to the map below, it has been found that the areas marked in gray shades have geothermal energy and are located in the west of the country (Bihor County, Arad, Timis and Satu Mare) and near Bucharest, more precisely in Ilfov County.

In order to increase the sustainability and viability of the model it was proposed to the governmental factors, the subsidization of the households in the counties that have, according to the map below, the benefits of this type of energy, for the purchase of some systems of valorization of this resource. For example, the counties that can benefit from such subsidies for green energy are: Bihor, Arad, Timis, Satu Mare and Ilfov. Geothermal energy can be used as a ventilation heating system with air conditioning systems to exploit geothermal energy on the surface.

In Romania, the Panonian Depression (Banat and western Apuseni mountains) is rich in geothermal deposits (Figure 3). In Timisoara there are geothermal resources with temperatures up to 80 °C.

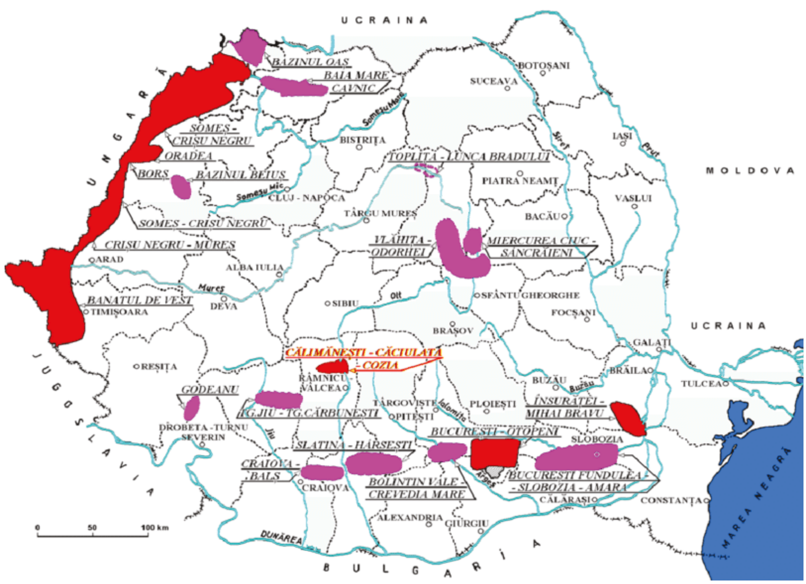

Figure 3. Map of geothermal potential in Romania. Source: [68] https://www.researchgate.net/figure/Repartition-of-geothermal-resources-in-Romania_fig1_312284159.

Wind power is a renewable energy source generated by wind power. The advantages of using wind energy are the following:

(i) The use of renewable resources is addressed not only to the production of energy, but through the particular way of generation it also reformulates the development model by decentralizing the sources;
(ii) Reduced costs per unit of energy produced;
(iii) Zero emission of polluting substances and greenhouse gases, due to the fact that they do not burn fuels;
(iv) Green energy source, no waste, is produced. To capture and harness this type of energy, wind turbines will be used to generate electricity.

Wind turbines-also known as windmills-transform the kinetic energy of the wind into mechanical energy, which is in turn, further transformed into electricity. Electricity is produced by a system using a charging regulator and it is stored in different ways. Thus, through this model we propose a solution for subsidizing households in counties that have this type of energy. In this sense, the inhabitants of these counties will be able to benefit from low rates for electricity. For example, the areas that could benefit from such subsidies for the implementation of wind systems for electricity production are Constanta, Bistrita-Nasaud, Braila, Tulcea, Vaslui, Ialomita and Galati (Figure 4).

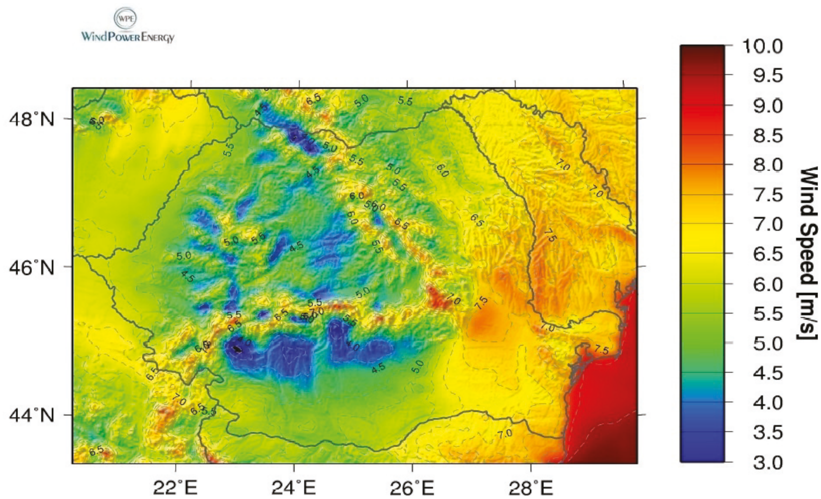

Figure 4. Map of the wind speed in Romania; Source [69] http://energielive.ro/energie-eoliana-harta-de-vant-a-romaniei-potential-de-14-000-mw/harta-vant-romania/.

The current structure of the natural gas market in Romania comprises (Figure 5):

- ➢ 1 operator of the National Transport System-SNTGN Transgaz SA Medias;
- ➢ 6 natural gas producers: OMV Petrom SA, SNGN Romgaz SA, SC Amromco SRL, SC Foraj Sonde SA, SC Raffles Energy SRL, Stratum Energy Romania LLC Wilmington Bucharest Branch;
- ➢ 2 operators for underground storage depots: SNGN Romgaz-Underground Storage Branch of Ploiesti Natural Gas, SC Depomures GDF Suez;
- ➢ 38 natural gas distribution and supply companies-the largest being SC Distrigaz Sud Retele SRL and SC Delgaz Grid SRL;
- ➢ 75 suppliers operating in the wholesale market.

The internal market for natural gas has two components:

- ➢ the competitive segment comprising:
- ➢ the wholesale market that operates on the basis of:
- ✓ bilateral contracts between economic operators in the field of natural gas;
- ✓ transactions on centralized markets, administered by the natural gas market operator or the equilibrium market operator as appropriate;
- ✓ other types of transactions or contracts.
- ➢ the retail market where suppliers sell natural gas to final customers through contracts at negotiated prices.
- ➢ the regulated segment that includes the activities of a natural monopoly, the activities related to them and the supply at regulated prices and based on the framework contracts approved by ANRE.

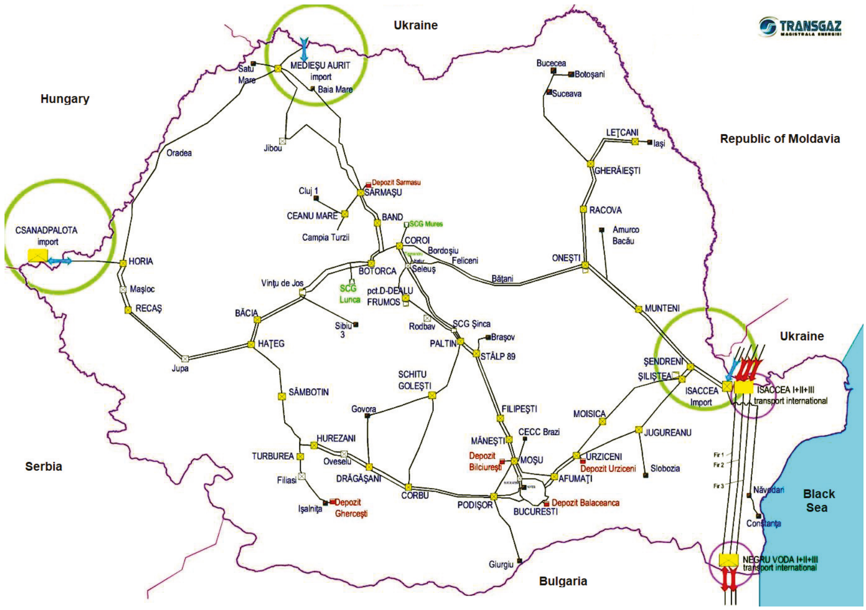

Figure 5. Map of the natural gas transmission network in Romania; Source [70] https://www.transgaz.ro/sites/default/files/uploads/users/admin/plan_de_dez_2017_-_2026.pdf.

Following the analysis of the data presented above, the transformation and synthesis of the values may be observed n showing Table 8.The analysis is necessary in order to come to the demographic areas of the country and the potential of accessing the different alternative sources of energy of the consumption of natural eyes, recommendations can be issued in order to be able to method us and the technologies, to take care to have the main objective population in ensuring comfort in households, implicitly the phenomenon of energy poverty.

Based on the synthesized information, correlated proposals can be made, depending on the values of population incomes from different areas of the country and the potential of energy sources (natural gas vs. alternative energy sources), regarding the opportunity to subsidize different technologies that allow access to the energy needed for the households comfort in different areas of Romania.

Considering the geographic profile of Romania, it can be observed, from the analysis of the previous data, that there are areas where access to transport and distribution networks, for natural gas to consumers is impossible or possible, but with very high costs.

By superimposing the map with the national network of natural gas transmission and distribution buses with the other maps with energy potential from other sources, largely renewable and environmentally friendly, policies can be issued correlated with the level of population incomes, at government level and ministerial, regarding the support of the population, in a sustainable way, by granting subsidies for the implementation of technologies, that allow the access to the sources of alternative energy, that fight the phenomenon of energy poverty.

In addition, where possible, it is preferable to replace the consumption of natural gas with green or renewable energy sources, which are more environmentally friendly, leading of course to reducing the greenhouse effect on the planet.

Table 8. Information on population incomes and energy potential in Romania.

Romanian's Counties	Net Income Lei* per Habitant	Sun Power kWh/m^2	Wind m/s	Geothermal T (°C)	Natural Gas
Alba	2023	1300	7		1131.06
Arad	2133	1370	5	80	137.06
Arges	2222	1320	5		265.89
Bacau	2047	1300	8		358.46
Bihor	1900	1290	7	85	220
Bistrita-Nasaud	1871	1250	9		501
Botosani	1921	1270	7		52.9
Braila	1840	1390	9		100.12
Brasov	2383	1300	8		912.22
Buzau	1890	1390	8		342.04
Calarasi	2013	1400	6		31.76
Caras-Severin	1912	1300	7		199.31
Cluj	2670	1290	3		533.83
Constanta	2126	1450	10		103.77
Covasna	1837	1290	5		159.76
Dambovita	1946	1370	4		1232.65
Dolj	2082	1400	5		171.9
Galati	2193	1410	8		137.51
Giurgiu	1895	1420	6		115.93
Gorj	2193	1300	3		891.04
Harghita	1791	1250	5		436.95
Hunedoara	1966	1220	5		555.65
Ialomita	1824	1390	8		106.52
Iasi	2278	1280	7		467.89
Ilfov	2913	1400	5	45	676.99
Maramures	1837	1190	4		692.66
Mehedinti	2161	1390	5		10.57
Mures	2128	1320	4		2733.31
Neamt	1883	1330	6		212.2
Olt	2148	1400	6		299.06
Prahova	2189	1370	4		1526.99
Salaj	1915	1300	5		252.44
Satu Mare	1936	1330	5	80	269.88
Sibiu	2468	1290	4		929.12
Suceava	1833	1240	6		183.89
Teleorman	1780	1400	4		21.28
Timis	2501	1340	5	75	234.37
Tulcea	1937	1400	9		33.74
Vaslui	1882	1380	8		91.52
Valcea	1870	1370	5		362.01
Vrancea	1890	1380	6		46

* 1 Euro = 4.85 Lei. Source [66] https://www.gfk.com/ro/noutati/comunicate-de-presa/puterea-de-cumparare-a-romanilor-a-crescut-in-2018-dar-odata-cu-ea-si-polarizarea-regionala.

For each county of the country, as shown in Table 9, alternative solutions for granting, subsidies are correlated with the incomes, in parallel and/or combined with the expansion of the natural gas transmission and distribution networks can be proposed to allow access easy for the population to source of energy.

Table 9. Proposals for subsidizing the technologies for obtaining the energy from various sources taking into account the area alternatives.

Romanian's Counties	Solutions for Improving Access to Energy/Combating Energy Poverty
Alba	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy) and sunshine (solar energy).
Arad	In addition to extend the natural gas distribution networks, subsidies may be granted for the installation of technologies that harness the force of the wind (wind energy), the heat of the ground water (geothermal energy), and the sun (solar energy).
Arges	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Bacau	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Bihor	In addition to expand the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the heat of the water from the earth (geothermal energy).
Bistrita-Nasaud	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Botosani	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Braila	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Brasov	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Buzău	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Calarasi	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Caras-Severin	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Cluj	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy) and sunshine (solar energy).
Constanta	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy) and wind power (wind energy).
Covasna	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Dambovita	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).

Table 9. *Cont.*

Romanian's Counties	Solutions for Improving Access to Energy/Combating Energy Poverty
Dolj	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Galati	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Giurgiu	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Gorj	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Harghita	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Hunedoara	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Ialomita	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy) and wind power (wind energy).
Iasi	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Ilfov	In addition to expand the natural gas distribution networks, subsidies can be awarded for the installation of technologies that harness the heat of the water from the earth (geothermal energy) and solar (solar energy).
Maramures	In addition to expand the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the heat of the water from the earth (geothermal energy).
Mehedinti	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Mures	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy) and sunshine (solar energy).
Neamt	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Olt	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Prahova	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Salaj	In addition to expand the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the heat of the water from the earth (geothermal energy).

Table 9. *Cont.*

Romanian's Counties	Solutions for Improving Access to Energy/Combating Energy Poverty
Satu mare	In addition to expand the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the heat of the water from the earth (geothermal energy).
Sibiu	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy) and wind power (wind energy).
Suceava	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Teleorman	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Timis	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the heat of the water from the earth (geothermal energy), and sunshine (solar energy).
Tulcea	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy) and wind power (wind energy).
Vaslui	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).
Valcea	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the sun (solar energy).
Vrancea	In addition to extend the natural gas distribution networks, subsidies can be granted for the installation of technologies that harness the force of the wind (wind energy).

Considering the above figure (Figure 6), it may be noticed that a very large number of wind projects-so the areas suitable for subsidizing this type of renewable energy-are found in Dobrogea, Moldova and Transylvania. In addition, photovoltaic projects are also a good alternative in areas where they can be installed, especially the southern areas of the country such as Danube Delta, Dobrogea and Romanian Plain. Renewable alternatives for geothermal projects can be found in Western Plain and Panonian Depression (Banat and Western Apuseni Mountains) and Romanian Plain, respectively Ilfov.

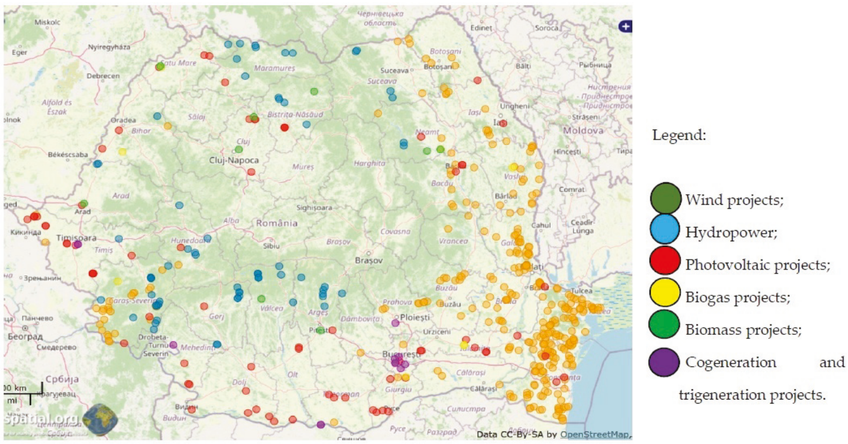

Figure 6. Interactive map of Romania's renewable energy projects; Source [67] https://www.fabricadecercetare.ro/regenerabil/.

The use of renewable energy sources-and the transition to the green economy-implies not only broad structural, institutional, technological, social, economic changes targeting the energy sector, transport, housing stock, equipment used by the population and companies in different fields, but also the behavior of consumers who must become more responsible in use of energy [68–77]. Modern societies must move towards an inclusive energy transition path that is achieved, on one hand, by reducing energy poverty, and on the other hand by controlling the impact of energy production and consumption on the environment through carbon emission [78–81].

7. Conclusions

Energy poverty is a dynamic and complex phenomenon with peculiarities depending on geographic location and level of development of each country. Energy poverty is generated by a combination of factors, namely low household incomes, high energy prices and poor access to the energy system for reasons other than lack of money and housing-specific energy shortages. Therefore, the financial situation of consumers, energy quality of the housing environment and the existence of a deficient energy system generate this phenomenon that occurs in both developed and developing countries, both in cold and warm areas.

Energy poverty is a multifaceted phenomenon because it affects different categories of people, involving numerous factors that generate consumer vulnerability. The heating and lighting needs of people-and the need for energy to power various appliances-are generated by the structure of households (the existence of several generations-the elderly and children with different needs), the state of health that could induce special requirements to ensure a certain temperature in the home or the professional status of household members (employees working from home, unemployed).

Solutions to solve this problem must be adapted to the specifics of each category of vulnerable consumers (urban or rural), and require the involvement of many categories of stakeholders such as local communities, NGOs, banks that must have adapted credit offers, public institutions which provides the legal framework, but also possible subsidies to encourage the production and use of renewable energy. As society develops, we will probably witness a paradigm shift in the sense of promoting and using the concept of well-being energy, so as to take into account not only the degree of satisfaction of needs, but also efficiency energy use.

Until such time as aggregate models or indicators will be able to sufficiently take all levels, dynamics and structure of energy poverty into account, we believe that an approach adapted to local specificities is necessary. For example, the same model of energy poverty and fuel poverty cannot be applied to a highly developed urban community in Europe, and at the same time, to a rural community in developing country, where households use woody biomass for heating and are often illegally connected to the electricity grid. Both in the effort to assess energy poverty and in trying to find solutions to these issues, a regional or local approach is needed that includes a series of indicators (in turn difficult to record and analyze) with reference to the cultural model, habits consumption, real incomes of households (not just declared or registered). Concerning the fight against energy poverty, on one hand, macro-solutions (i.e., the strategic approach, highlighted by the government policies to increase the level of energy independence by accessing and exploiting all available resources, obviously in environmentally friendly conditions) were highlighted. On the other hand, the micro-solutions (which focus on identifying vulnerable consumers and target their specific needs through joint efforts of local governments, civil society and economic agents) were also explored.

According to the results of the pairwise Ganger causality test, causality relations were found between pairs of variables. A causality circuit appeared: GDP Granger-caused electricity prices for households, electricity prices for households Granger-caused arrears on utility bills, arrears on utility bills Granger-caused GDP.

Taking into account the above, in the case study in Section 6-based on the synthesized information-proposals were made to access different sources of alternative energy. These were made in correlation with the population's income levels in the different areas of the country-and the potential of energy resources (natural gas vs. alternative energy sources), in terms of the opportunity to subsidize various technologies that allow access to the energy needed for the comfort of households in different areas of Romania. In these cases of accessing alternative energy sources (wind, sun, geothermal, etc.), even if the initial material efforts are high, the results are remarkable:

- ➢ Increasing the quality of life by reducing the effects of the energy poverty phenomenon;
- ➢ Protecting the environment by reducing the effects of the use of polluting resources.

In conclusion, this case study, through the proposed solutions, brings a plus for the social framework and also for the environment.

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Productive Employment for Inclusive and Sustainable Development in European Union Countries: A Multivariate Analysis

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Abstract: It is widely recognized that achieving highly productive employment is a serious challenge facing inclusive and sustainable development. In this context, the aim of this article was to highlight the main characteristics and mechanisms of productive employment, focusing on the interrelationships between productive employment, and inclusive and sustainable development in European Union countries, during the recent economic crisis and recovery period (2007–2016). The results of the correlation and regression analysis suggest that the high level of inclusive and sustainable development in some European Union countries can be mainly explained by high labor productivity, an efficient sectoral structure of employment, a low level of vulnerable and precarious employment, and low working poverty. Moreover, the results of the principal component analysis and cluster analysis show that there are common features and differences between the European Union member states in terms of their interrelationship between productive employment, and inclusive and sustainable development, which emphasizes the need to take specific actions to transform unproductive employment into productive employment, especially in southern countries and some central and eastern European countries, so that productive employment will be the driving force for development.

Keywords: inclusive and sustainable development; productive employment; labor productivity; sectoral structure of employment; working poverty; correlation and regression analysis; principal component analysis; cluster analysis

1. Introduction

"Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all" is one of the main goals of the 2030 Agenda for Sustainable Development (Goal 8) adopted by the member states of the United Nations [1]. According to the Europe 2020 Strategy [2], the European Union (EU) aims "to become a smart, sustainable, and inclusive economy delivering high levels of employment, productivity, and social cohesion". Thus, the central role of productive employment in inclusive and sustainable development is recognized both worldwide and at the EU level.

Sustainable development is a complex and multidimensional concept [1,3,4], which implies at least three dimensions of development: economic, social, and ecological [5,6]. Empirical research [4,5] shows that there are trade-offs in favor of the economy at the cost of social wellbeing and ecological viability, which can affect the achievement of sustainable development. Inclusive development can be defined as development that "includes marginalized people, sectors, and countries in social, political, and economic processes for increased human wellbeing, social and environmental sustainability, and empowerment" [7] (p. 546). Thus, we consider that national and international strategies should pay attention to both sustainable development and inclusive development in order to ensure a high living standard and quality of life for all people.

Sustained and sustainable gross domestic product (GDP) per capita growth, growth in productive employment, sustained reduction in income poverty and inequality, sustainable improvement in human development indicators, and basic social protection for all are the essential elements of inclusive growth and development [8–12]. Productive employment is seen as a critical nexus between growth and poverty reduction [13]. In the World Bank report [14], it is underlined that jobs are the cornerstone of economic and social development. Although productive employment and inclusive growth are actually widespread in development policies, productive employment "is still more widespread as an aspiration than as a reality in large parts of the global South" [15] (p. 2).

Europe's past experience demonstrates that the quality of available jobs is a matter for concern [16], not only in terms of pay and job security [17]. Because of a relative expansion of low-quality jobs, employment growth was not accompanied by a significant reduction in poverty [18]. A critical barrier impeding poverty reducing through sustainable employment [19] is working poverty (or in-work poverty), as a form of deficit in productive employment [20]. According to statistical data [21], in the recent economic crisis and recovery period (2007–2016), working poverty increased in most of the EU member states, and the incidence of in-work poverty varies significantly across these countries. Behind these differences, there are specific determinants that require specific measures [22]. The existence of working poverty (the latest Eurostat figures point out that 9.6% of EU workers are affected by risk of poverty [21]) proves that getting people into work is not always enough to avoid poverty risk. Therefore, actions to translate unproductive employment into productive employment are needed. Also, EU statistics [21] show large differences between countries in meeting the targets of the Europe 2020 Strategy [2] in terms of employment, research and development, climate change and energy, education, poverty, and social exclusion; while some EU member states moved toward the targets, others moved away from them. Taking into account that the new member states of the European Union, especially central and eastern European (CEE) countries, was lagging behind the old member states (EU-15) in their inclusive and sustainable development and competitiveness [21,23–25], we consider that more attention needs to be paid to improve productive employment as a key precondition for achieving economic, social, and territorial cohesion at the EU level in order to reduce disparities between individual member states and to ensure a high level of inclusive and sustainable development in all countries of the EU.

In the light of these considerations, the aim of this article was to highlight the main characteristics and mechanisms of productive employment in relation to inclusive and sustainable development, in the EU countries for the 2007–2016 period, in order to identify some possible measures that need to be taken to improve productive employment and its effect on inclusive and sustainable development. The research objectives focused on (i) analyzing the link between labor productivity and the national level of inclusive and sustainable development; (ii) exploring the sectoral structure of employment and its implications on labor productivity; (iii) investigating working poverty (deficit in productive employment) and the inclusive development nexus; (iv) identifying the common features and differences between EU member states relative to interrelationships between productive employment, and inclusive and sustainable development.

The novelty of this research consists in the multivariate analysis of the interrelationship among productive employment, and inclusive and sustainable development in the EU countries, in the recent economic crisis and recovery period (2007–2016), based on correlation and regression analysis, principal component analysis (PCA), and cluster analysis (CA). Since productive employment is a major challenge for the EU economies (and others), understanding its main characteristics and mechanisms can be a contribution to the development of the literature and an important step in designing more effective policies so that productive employment becomes a driving force for the achievement of inclusive and sustainable development.

2. Theoretical Background and Research Hypotheses

In the literature on employment, productive employment is presented as a driving force for inclusive and sustainable development [8,11,20,26,27]. According to the International Labor Office (ILO) definition [20] (p. 3), productive employment is that employment which yields "sufficient returns to labor to permit workers and their dependents a level of consumption above the poverty line", and includes three dimensions: remuneration, stability of employment, and working conditions [9]. Moreover, it is the crucial element that links economic growth to development and poverty reduction, and which, combined with social protection, provides the main means of reducing poverty [20].

Empirical evidence shows that a real challenge for national economies is their reduced capacity in terms of generating employment growth while in a process of economic growth [8,28,29], emphasizing the lack of inclusive economic growth and development [30]. This fact can generate a high level of inequality and poverty, and insufficient productive opportunities for employment [31]. Taking into account that economic growth by itself may not be inclusive and sustainable [32], the nature and pattern of economic growth matters for employment creation and poverty reduction.

The World Bank report [14] highlights that the jobs that contribute the most to development are those that enhance the functioning of cities, create a link between the economy and the global markets, promote cooperation and civic engagement, and are environmentally friendly and help diminish poverty. In the same report [14], it is stated that "good jobs for development" are those jobs that significantly contribute to the development of a society. Access to productive employment provides the poor with better income, as well as stimulating learning and skills acquisition, which is essential for the inclusion of the poor in society [9].

In order to measure productive employment, as a key driver of development, three main indicators are used [20,33]: labor productivity, the proportion of vulnerable workers (the proportion of own-account and contributing family workers in total employment), and the share of working poor (working poverty rate).

Economic growth and development, competitiveness, and living standards within an economy depend on labor productivity [8,11,15,34], and workers are more productive if they work with better equipment and are more efficient if they benefit from education and training [35].

The level of an economy's productivity is considered the heart of competitiveness [36] and "the prime determinant of a nation's long run standard of living" [34] (p.76). Moreover, The Europe 2020 Competitiveness Report [36] highlights a high level of interaction between competitiveness and sustainable and inclusive development, taking into account that competitive economies "are those that are able to provide high and rising living standards, allowing all members of a society to contribute to and benefit from these levels of prosperity" [36] (p. 5), as well as those economies that meet "the needs of the present generation while not compromising the ability of future generations to meet their needs" [36] (p. 5).

An improvement in labor productivity and quality of jobs is often interlinked with structural transformation [16,37,38]. As Porter [34] showed, differences in national economic structures alongside the differences in national values, culture, and institutions have an important contribution to competitive success of nations. Moreover, Porter identified the differences in the patterns of competitiveness in every country [34]. A major element of structural transformation is the gradual reallocation of workers and other resources from traditional activities, with low productivity (agriculture and low value-added manufacturing), to modern activities, characterized by higher productivity (high value-added manufacturing and services) [39]. According to the World Economic Forum, which adapts Porter's theory of development stages [34], as a country becomes more competitive and moves along the development path, from the factor-driven stage into the efficiency-driven stage and then into the innovation-driven stage, productivity will increase and wages will increase as well [40]. Moreover, Erkut [41] states that the transformation of a national economy from one stage of competitiveness and development to the other "can be interpreted within the context of a self-organized economic evolution" [41] (p. 86).

The fact that structural transformation is not a mechanical process is acknowledged and it is often significantly different from the approach adopted by the developed countries over the last century [16]. In most developing countries, there was a premature deindustrialization process, expressed by reducing shares of both employment and output in the manufacturing sector, but at a low level of economic development, which had important consequences for the pace of development and the type of employment generated [16,37]. Lehmann-Waffenschmidt [42], based on the contingency approach and the structural similarity approach, emphasized that laying the foundations of successful industrialization and growth processes takes a long time and this cannot be replaced by a short-term political intervention, but he also adds another important factor, i.e., a sufficiently high rate of technical progress and innovation.

The impact of improvements in labor productivity on inclusive development is strongly linked to the sector that generates economic growth [43]. The countries that manage to increase productivity and pull out of poverty are those that were able to diversify away from agriculture and other traditional sectors [16,28,38]. A strong negative correlation between economic development (GDP per capita) and shares of agriculture in GDP [9] and in employment [44] were found, which can be explained by the significant contribution of agriculture to employment, in countries with low economic development. A real challenge facing employment in agriculture is its low quality due to the low productivity in traditional activities [9,44]. There is a strong association between productive structural transformation and job quality, expressed by a high share of wage and salaried workers or, equivalently, a low share of vulnerable employment in total employment [33]. Thus, as labor moves from the agricultural sector (characterized by a high degree of vulnerable employment and low productivity) to the manufacturing and/or services sector, the share of wage workers (better-quality jobs) tends to increase and the share of vulnerable workers (own-account workers and contributing family workers) tends to decrease [33]. Also, evidence points to a strong negative relationship between the incidence of vulnerable employment and the level of development [16]. Vulnerable workers were more affected by relative poverty than wage and salaried workers, who benefit from greater employment security [8,33,45]. The vast majority of the working poor work in agriculture and rural areas [8,44]. Moreover, structural transformation drives profound changes in the labor market, especially shifting from the standard employment relationship (permanent jobs, full-time, employee status, etc.) to the non-standard employment relationship (temporary work, part-time, self-employment, etc.), which may increase vulnerability of work [22,46,47], leading to an increase in working poor.

As regards the main causes and mechanisms of working poverty, as a form of deficit in productive employment, the literature is very broad [8,18,22,45,48,49], encompassing low pay (which is usually associated with low levels of productivity), temporary and part-time work, personal characteristics and professional status of employed persons, household structure of the person working, and different dysfunctions of the labor market and welfare states regimes.

Empirical results [8,22,30,33] showed a positive two-way relationship between job quality and per capita income. Moreover, it is underlined that sustainable development cannot be achieved unless it goes hand in hand with decent and productive work [33]. Moreover, the potential of structural transformation to create more and better jobs is essential in generating sustained economic development and improving living standards [16]. Therefore, the movement of workers from agriculture to services reflects the growth of productive jobs, especially when workers relocate into high-productivity services sectors, such as knowledge-intensive services (KIS) [16,50]. Some authors [8,50] found, at the EU-27 level, a strong positive relation, in both directions, between the employment in KIS, on the one hand, and economic development (GDP per capita) and labor productivity, on the other hand. According to McMillan et al. [51], sustained economic development requires employment to be directed toward modern sectors and to be backed by actions that would foster the productivity of each economic activity, such as making investments in technology upgrading, skill development, and last but not least institutional capabilities. Lavopa and Szirmai [52], analyzing the link between trajectories of structural modernization and the ability of countries to escape poverty, pointed out that expanding the size of the modern sector is not sufficient to ensure a steady growth, as a process of technology absorption is needed in order to reduce the technology gap. Economic development and labor productivity are highly related to the knowledge capital and innovation of the countries [53–56], since education, especially tertiary education, is seen as a driver of productivity and economic development in both developing and developed countries [57].

In light of these considerations, the fundamental research question of this study is as follows: which are the characteristics of productive employment in the EU member states and to what extent can productive employment be a driving force for the achievement of inclusive and sustainable development?

Based on the theoretical background and evidence from the literature, we formulated the following research hypotheses (H):

H1: *Labor productivity is higher in EU countries with high inclusive and sustainable development.*

H2: *There is a strong association between high labor productivity and an efficient sectoral structure of employment in the EU countries, during the 2007–2016 period.*

H3: *Working poverty (deficit in productive employment) influences the level of inclusive development negatively.*

H4: *A higher level vulnerable and precarious employment determines a high risk of working poverty in the EU countries, during the 2007–2016 period.*

H5: *There are common features and differences between EU member states based on their interrelationships between productive employment, and inclusive and sustainable development.*

3. Materials and Methods

In order to analyze the inclusive and sustainable development of the EU countries, we used gross domestic product (GDP) per capita (in purchasing power standards (PPS) as a percentage of EU-28 average GDP =100%), Human Development Index (HDI), Europe 2020 Competitiveness Index, and Inclusive Development Index (IDI). In our paper, we focus on the economic and human dimension of sustainable development. According to the Human Development Report [58], HDI integrates three basic dimensions of human development: the ability to lead a long and healthy life, the ability to acquire knowledge, and the ability to achieve a decent standard of living. As the World Economic Forum report [59] highlights, IDI is a composite index which comprises three pillars: growth and development, inclusion, and equity and sustainability. Four main indicators were chosen within each of the three pillars. Thus, the growth and development pillar consisted of GDP per capita, labor productivity, employment, and healthy life expectancy. The inclusion pillar included median household income, poverty rate, income Gini, and wealth Gini. The intergenerational equity and sustainability pillar incorporated adjusted net saving, public indebtedness as a share of GDP, dependency ratio, and carbon intensity of GDP [59]. The Europe 2020 Competitiveness Index "is grouped into three sub-indexes that monitor Europe's progress toward becoming an increasingly smart, inclusive, and sustainable economy" [59] (p.8), including seven pillars that reflect the spirit of the seven flagship initiatives: enterprise environment, digital agenda, innovative Europe, education and training, labourlabor market and employment, social inclusion, and environmental sustainability. IDI scores and Europe 2020 Competitiveness Index scores are based on a 1–7 scale, where 1 = worst and 7 = best.

Productive employment was analyzed based on five indicators related to employment issues: employment rate, labor productivity (GDP per employed person, as a percentage of EU-28 average = 100%), employment in services, employment in knowledge-intensive activities (KIA), and compensation of employees (percentage of GDP). A high level of these interrelated indicators reflects a high level of productive employment [16,33]. According to the Eurostat definition, "an activity is classified as knowledge-intensive if tertiary-educated persons employed (according to ISCED97, levels 5–6) represent more than 33% of the total employment in that activity" [21].

Employment in agriculture, vulnerable employment (own-account workers and unpaid family workers as a percentage of total employment), precarious employment (involuntary part-time employment), in-work at-risk-of-poverty rate, and at-risk-of-poverty rate were used for analyzing the deficit in productive employment and poverty (Table 1).

Table 1. Variables included in the principal component analysis (PCA) and cluster analysis (N = 25). Descriptive statistics (2007–2016 average).

Variables	Minimum	Maximum	Mean	Standard Deviation
Productive employment				
Employment rate [1]	59.34 (EL)	79.72 (SE)	69.41	5.53
Labor productivity [2]	41.96 (BG)	150.04 (IE)	92.16	26.27
Employment in services [3]	41.45 (RO)	82.23 (NL)	68.62	9.79
Employment in KIA [3*]	20.08 (RO)	43.22 (SE)	34.11	5.52
Compensation of employees [4]	33.74 (RO)	52.32 (DK)	44.53	5.77
Deficit in productive employment and poverty				
Employment in agriculture [3]	1.32 (UK)	29.24 (RO)	6.95	6.41
Vulnerable employment [5]	5.24 (EE)	30.88 (RO)	12.12	6.40
Involuntary part-time employment [6]	7.83 (NL)	60.29 (EL)	30.31	16.33
In-work poverty rate [8**]	3.77 (CZ)	18.44 (RO)	8.07	3.31
At-risk-of-poverty rate [9**]	9.33 (CZ)	23.59 (RO)	16.59	3.91
Inclusive and sustainable development				
GDP/capita [7]	45.2 (RO)	143.6 (IE)	92.31	28.78
HDI (0–1 values)	0.78 (BG)	0.92 (DK)	0.86	0.04
Europe 2020 Competitiveness Index	3.64 (RO)	5.7 (FI)	4.56	0.62
Inclusive Development Index (IDI)	3.7 (EL)	5.81 (DK)	4.88	0.53

Notes: [1] percentage of population aged 20 to 64; [2] per person employed (EU28 = 100%); [3] percentage of total employment; [4] percentage of GDP; [5] the share of own-account workers and contributing family workers, in total employment; [6] percentage of total part-time employment; [7] in purchasing power standards (PPS) as percentage of EU-28 average GDP = 100%; [8] "the share of persons who are at work and have an equivalized disposable income below the risk-of-poverty threshold" [21]; [9] people at risk of income poverty after social transfers; * "an activity is classified as knowledge-intensive if tertiary educated persons employed (according to ISCED97, levels 5–6) represent more than 33% of the total employment in that activity" [21]; ** at-risk-of-poverty threshold iswas set at 60% of the national median equivalized disposable income [21]; BG—Bulgaria, CZ—Czech Republic, DK—Denmark, EE—Estonia, EL—Greece, FI—Finland, IE—Ireland, NL—Netherlands, RO—Romania, SE—Sweden, UK—United Kingdom. Source: own calculations based on References [21,36,58,60].

Our sample consisted of 25 countries from the EU, without Malta, Cyprus (the countries for which more statistical data are unavailable), and Luxembourg (an outlier in many variables). Statistical data on the analyzed variables were collected from the Eurostat Database [21], United Nations Development Program (UNDP) Report [58], and World Economic Forum (WEF) reports [36,60] for the 2007–2016 period.

In order to test the research hypotheses, we used descriptive statistics, correlation and regression analysis, principal component analysis (PCA), and cluster analysis (CA).

We applied the Pearson correlation coefficient (r) to study the intensity of the relationship between variables. The value of the correlation coefficient was situated in the interval (-1, $+1$). A value of $+1$ indicates a perfect positive linear relationship between variables. Conversely, a value of -1 indicates a perfect negative linear relationship between variables. Independence between the variables implies that the value of r is equal to zero [61].

We employed a simple linear regression analysis ($Y = \alpha + \beta \times X + \varepsilon$, where Y is the dependent variable, X is the explanatory variable, α and β are regression coefficients, and ε is the residual or error) and multiple linear regression analysis ($Y = \alpha + \beta_1 \times X_1 + \beta_2 \times X_2 + \varepsilon$) to identify a functional relationship between the analyzed variables. The regression coefficients were estimated using the least-squares method [62]. To assess the validity of the regression model, the Fisher Snedecor (F) statistic was used. Based on the R^2 (the coefficient of determination) value, the quality of prediction was assessed. The value of R^2 indicates the proportion of the variance in the dependent variable that the independent variables explain. The variance inflation factors (VIF) and the tolerance of the independent variables were tested in order to check if the results were affected by multicollinearity.

As Hair et al. [63] stated, a high multicollinearity could be met when the VIF has a value which is higher than 10 and the tolerance records a value which is less than 0.1.

In order to classify the EU countries and obtain a comparative view of their interrelation between productive employment, and inclusive and sustainable development, principal component analysis (PCA) and cluster analysis (CA) were used.

In the first step, PCA with Varimax rotation and Kaiser normalization was used to reduce the dimensionality of a dataset consisting of a large number of interrelated variables (14 variables) to a few factors or principal components [64]. The advantage of this multivariate technique consists of the reduction of the complexity of the data, producing a small number of derived variables that can be used instead of the larger number of original variables in order to simplify the subsequent analysis of the data [62]. In order to choose the number of principal components, we used multiple criteria such as the Kaiser criterion or eigenvalue-greater-than-one rule, as well as Catell's scree plot criterion and percentage of cumulative variance, based on which only the components which capture a large percentage of the total variation of the original variables (between 70 and 90%) are retained [62,64]. The choice of using PCA in this research took into consideration the fact that, in recent years, PCA was widely applied to the study of the social and economic differences and similarities between various nations [22,65–67]. Furthermore, PCA is recognized as a multivariate statistical method which contributes to solving the inconveniences generated by different measuring of original variables, data seasonality, and high variations of the covariance coefficients [65,68].

In the second step, the principal components that resulted from the PCA were used for the cluster analysis and this helped us identify the homogenous groups of countries. Therefore, at first, we used a hierarchical cluster analysis, using Ward's method and the Euclidian distance in order to determine the number of clusters. This method was followed by a k-means cluster analysis. Then, to identify the relatively homogeneous groups of cases based on the selected characteristics, k-means cluster analysis was used [22,69]. We used the SPSS statistical package for all statistical analyses.

4. Results and Discussion

In order to achieve an inclusive and sustainable development, it is necessary for economic growth to be accompanied by employment growth, on the one hand, and for the benefits of economic growth to be more equitably distributed, on the other hand. Based on the data provided by Figure 1 in the EU, during the 2007-2016 period, the process of economic growth (expressed by real GDP growth rate) varied substantially across countries, and this process was not accompanied by employment growth (in all 25 EU countries analyzed). Thus, in six of the 25 countries, despite an economic growth process, employment decreased, but labor productivity increased (Romania, Bulgaria, Spain, Estonia, Lithuania, and Latvia). It is confirmed that economic growth is a necessary but not sufficient condition for achieving substantial progress in living standards [10,59].

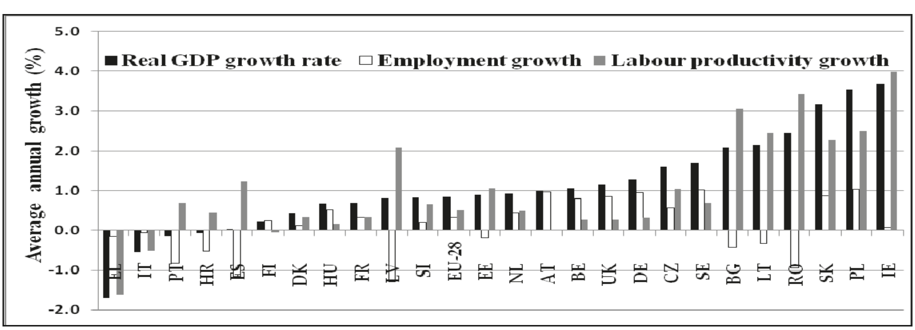

Figure 1. Real economic growth, employment growth, and labor productivity growth, in European Union (EU-25) countries, 2007–2016. Source: own calculations based on Reference [21].

Also, the "jobless growth" process is noticeable in 15 of the 25 countries, emphasizing the small capacity of economic growth to generate employment growth (annual average economic growth is higher than annual average employment growth). Four of the 25 countries recorded a decrease in both average employment growth and average economic growth (Portugal, Italy, Greece, and Croatia). It is worthwhile mentioning that the relationship between employment growth and economic growth is more complex, as large numbers of jobs are being created and destroyed simultaneously in the context of structural change and spatial labor reallocation [8,14].

In the same period, all countries (except Greece and Italy) recorded labor productivity growth which varied significantly across these countries (Figure 1). Moreover, statistical data point out the significant differences in terms of the level of labor productivity (Figure 2), which ranged from 42% to 150% (EU-28 = 100%). However, significant gaps can still be noted between the new member states and the old member states.

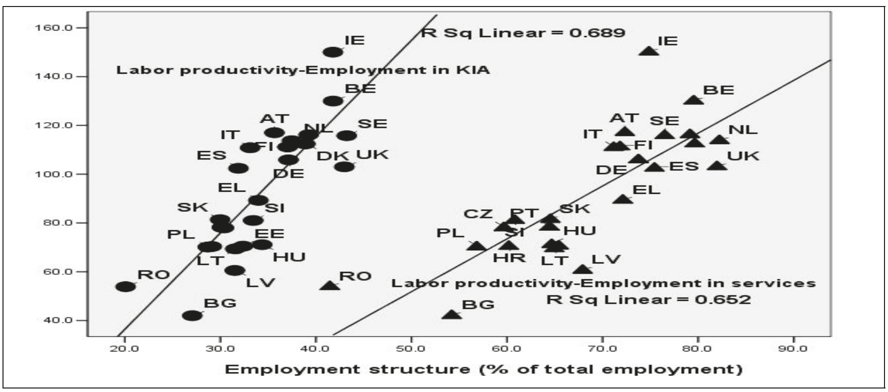

Figure 2. Relationship between labor productivity and employment in knowledge-intensive activities (KIA) and services, 2007–2016 average. Source: own calculations based on Reference [21].

The results of the correlation analysis (Table 2) show that, in the EU member states, during the 2007–2016 period, labor productivity was positively correlated with Europe 2020 Competitiveness Index (r = 0.693), GDP/capita (r = 0.952), HDI (r = 0.872), and IDI (r = 0.577). Thus, in the EU countries where labor productivity is higher (especially the developed economies of EU), the level of competitiveness, level of economic and human development, and level of inclusive development are also higher and vice versa, which confirms Hypothesis H1.

Table 2. Correlation between productive employment and inclusive and sustainable development.

Pearson Correlation (r)	GDP/ Capita	HDI	Europe 2020 Competitiveness Index	IDI	Labor Productivity
Labor productivity	0.952 *	0.872 *	0.693 *	0.577 *	1.000
Employment in services	0.807 *	0.815 *	0.728 *	0.481 **	0.808 *
Employment in KIA	0.832 *	0.831 *	0.766 *	0.624 *	0.830 *
Compensation of employees (% of GDP)	0.518 *	0.579 *	0.730 *	0.507 *	0.439 **

Notes: * correlation is significant at the 0.01 level (two-tailed); ** correlation is significant at the 0.05 level (two-tailed); IDI—Inclusive Development Index; HDI—Human Development Index. Source: Own calculations based on References [21,36,58,60].

As Table 2 and Figure 2 show, it appears that, in the EU, higher levels of labor productivity are linked to an efficient sectoral structure of employment, expressed by a higher share of employment in services (r = 0.807) and KIA (r = 0.832) in total employment, and by a lower employment in agriculture (r = −0.679).

The results of the simple linear regression analysis (Figure 2 and Table 3) show that, in the EU countries, the level of labor productivity is positively influenced by the level of employment in services. The simple linear regression model (labor productivity = −56.492 + 0.808 × employment in services) was statistically significant (F (1, 23) = 43.174; p = 0.000) and accounted for 65.2% of the variance of labor productivity (R^2 = 0.652).

Table 3. Simple regression results: the impact of employment in services on labor productivity.

Dependent Variable [1]	Unstandardized Coefficients		Standardized Coefficients	*t*-Statistics	Significance
	B	Standard Error	Beta		
Constant	−56.494	22.844		−2.473	0.021
Employment in services	2.166	0.330	0.808	6.571	0.000

Note: [1] labor productivity; R^2 = 0.652, adjusted R^2 = 0.637; standard error of the estimate = 15.818; F (1, 23) = 43.174, p < 0.001. Source: own calculations based on Reference [21].

Moreover, we analyzed the impact of the level of employment in KIA on labor productivity (Figure 2 and Table 4). The estimated simple linear regression model for the impact of the level of employment in KIA on labor productivity in the EU countries, during the 2007–2016 period (labor productivity = 42.640 + 0.830 × employment in KIA), highlights that employment in KIA positively influenced labor productivity (β = 0.830). This model was statistically significant (F (1, 23) = 50.93; p = 0.000 p = 0.000) and accounted for 67.5% of the variance of labor productivity (R^2 = 0.675).

Table 4. Simple regression results: the impact of employment in KIA on labor productivity.

Dependent Variable [1]	Unstandardized Coefficients		Standardized Coefficients	*t*-Statistics	Significance
	B	Standard Error	Beta		
Constant	−42.640	19.124		−2.230	0.036
Employment in KIA	3.951	0.554	0.830	7.137	0.000

Note: [1] labor productivity; R^2 = 0.689, adjusted R^2 = 0.675; standard error of the estimate = 14.966; F (1, 23) = 50.932, p < 0.001. Source: own calculations based on Reference [21].

These results show that, in the EU countries where employment in services and employment in KIA are higher, the level of labor productivity is high too, which confirms Hypothesis H2. This fact reflects the need to make the sectorial structure of employment more efficient in some EU countries, especially in new EU member states, so that they become developed economies in the context of sustainable development.

As it can be noted in Table 5, all four variables which reflect deficit in productive employment are negatively correlated with variables specific to economic, and inclusive and human development and competitiveness. A negative and significant correlation was identified between inclusive development (expressed by IDI), on the one hand, and working poverty, as a form of deficit in productive employment (r = −0.654, p < 0.01, Table 5) and overall poverty (r = −0.705, p < 0.01, Table 5), on the other hand.

Table 5. Correlation between deficit in productive employment and inclusive and sustainable development.

Pearson Correlation (r)	GDP/Capita	HDI	Europe 2020 Competitiveness Index	IDI	In-Work Poverty Rate
Employment in agriculture	−0.690 *	−0.748 *	−0.665 *	−0.552 *	0.678 *
Vulnerable employment	−0.333	−0.317	−0.559 *	−0.621 *	0.706 *
Involuntary part-time employment	−0.467 **	−0.540 *	−0.594 *	−0.719 *	0.679 *
In-work poverty rate	−0.455 **	−0.442 **	−0.501 **	−0.654 *	1.000
At-risk-of-poverty rate	−0.564 **	−0.597 *	−0.523 *	−0.705 *	0.771 *

Note: * correlation is significant at the 0.01 level (two-tailed); ** correlation is significant at the 0.05 level (two-tailed); IDI—Inclusive Development Index; HDI—Human Development Index. Source: own calculations based on References [21,36,58,60].

Using a simple regression of IDI on in-work poverty rate (Figure 3 and Table 6) points out that working poverty influenced IDI negatively and significantly ($\beta = -0.654$, $p = 0.000$). The IDI regression model was statistically significant (F (1, 23) = 17.195, $p = 0.000$; $R^2 = 0.428$). Thus, the low level of inclusive development in the EU countries can be explained by the existence of high working poverty rate. Taking account of these results, Hypothesis H3 is confirmed.

Table 6. Simple regression results: the impact of in-work poverty rate on IDI.

Dependent Variable [1]	Unstandardized Coefficients		Standardized Coefficients	*t*-Statistics	Significance
	B	Standard Error	Beta		
Constant	5.718	0.219		26.102	0.000
Employment in KIA	−0.104	0.025	−0.654	−4.147	0.000

Note: [1] IDI, Inclusive Development Index; R^2 = 0.428, adjusted R^2 = 0.403; standard error of the estimate = 0.408; F (1, 23) = 17.195, $p < 0.001$. Source: own calculations based on Reference [21].

Furthermore, Figure 3 shows how the level of working poverty varies across countries. The highest in-work at-risk-of-poverty rate from EU-28 was recorded in Romania (18.44%), followed by the southern countries (Greece, 13.71%; Spain, 11.5%; Italy, 10.52%; Portugal, 10.47%) and Poland (10.04%). In-work at-risk-of-poverty rate in Romania was 2.07 times higher than the European average (8.89%) and almost five times higher than in the Czech Republic (3.77%), the most efficient European country from this perspective. Thus, working poverty is a real socio-economic challenge at the European level, confirmed by other studies [16,22,45,49].

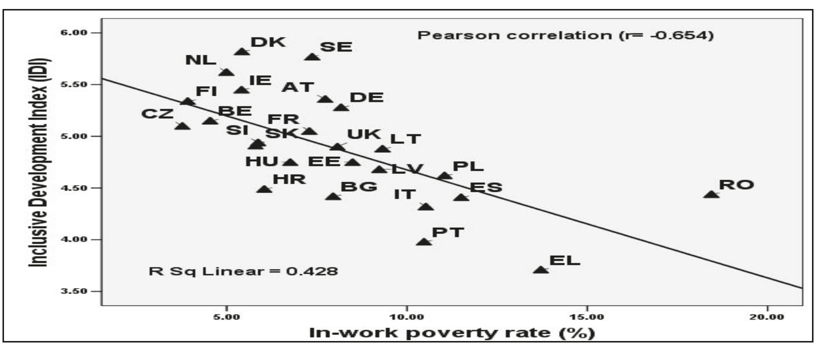

Figure 3. In-work poverty rate and Inclusive Development Index (IDI) in EU countries. Source: own calculations based on References [21,60].

In order to test Hypothesis H4, we estimated the influence of vulnerable employment (own-account workers and unpaid family workers) and precarious employment (involuntary part-time employment), as independent variables, on working poverty, using multiple regression analysis (Table 7). The regression model was statistically significant (F (2, 22) = 19.531, $p < 0.001$) and accounted for over 60% of the variance of working poverty (R^2 = 0.640, adjusted R^2 = 0.607). As can be seen by examining the beta weights (β), vulnerable employment received the strongest weight in the model (β = 0.489), followed by involuntary part-time employment (β = 0.434), implying that vulnerable employment has a greater impact on working poverty. In the EU countries, during the 2007–2016 period, higher vulnerable and precarious employment determined a high risk of working poverty. Thus, hypothesis H4 is confirmed and supported by other empirical results [22,45,49]. Corroborating these results with the positive link between vulnerable employment and employment in agriculture ($r = 0.644$, $p < 0.01$), it is shown that, in EU countries, during the 2007–2016 period, vulnerable workers, mainly those who work in agriculture, suffered the consequences of working poverty risk. Moreover, this implies that both agricultural productivity and the income for agricultural workers need to increase to reduce working poverty [44].

Table 7. Multiple regression results.

Dependent Variable [1]	Unstandardized Coefficients		Standardized Coefficients	*t*-Statistics	Significance	Collinearity Statistics	
	B	Standard Error	Beta			Tolerance	VIF
Vulnerable employment	0.253	0.077	0.489	3.309	0.003	0.750	1.334
Involuntary part-time employment	0.088	0.030	0.434	2.935	0.008	0.750	1.334

Note: [1] working poverty; constant = 2.332908, R^2 = 0.640, adjusted R^2 = 0.607, F (2, 22) = 19.531, $p < 0.001$; variance inflation factors (VIF). Source: own calculations based on Reference [21].

In order to test Hypothesis H5, we took into consideration the cumulative influence of 14 socio-economic variables selected, the inclusive and sustainable development indicators, productive employment indicators, and indicators which reflect the deficit in productive employment and poverty (see Table 1), employing complex statistical methods of data analysis, principal component analysis (PCA), and cluster analysis, respectively. Based on PCA (rotation method: Varimax with Kaiser normalization; rotation converged in three iterations), the 14 variables were grouped into two components (factors), which explain 76.63% of the total variance of the 14 initial variables (Tables 8 and 9).

Table 8. Total variance and eigenvalues explained.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.992	64.226	64.226	5.610	40.071	40.071
2	1.736	12.401	76.626	5.118	36.555	76.626
…	…	…	…			
14	0.006	0.046	100			

The first principal component (PC1), which explains 64.23% of total variance, includes seven variables (Table 9). Six of these variables can be specific to an efficient employment, having a positive influence on national competitiveness and development: employment in services, KIA employment, labor productivity, GDP/capita, HDI, and Europe 2020 Competitiveness Index. This component (PC1) is negatively correlated with the employment in agriculture. Thus, a high level of employment in agriculture cannot be associated with economic and human development. The second principal component (PC2) explains 12.4% of total variance of the 14 original variables and includes seven variables: involuntary part-time employment, in-work poverty rate, vulnerable employment, IDI, employment rate, total poverty rate, and compensation of employees (Table 9). Three of these variables reflect a deficit in productive employment directly (in-work at-risk-of-poverty rate) or indirectly (vulnerable employment and involuntary part-time employment) and have a negative contribution to the creation of this component. Other variables (employment rate, IDI, and compensation of employees) have a positive contribution to the creation of PC2 (Table 9).

The two principal components were used in the cluster analysis to classify the EU countries. We used hierarchical cluster analysis, Ward's method, and Euclidean distance to define the number of clusters in which the 25 countries were classified. Then, we used the k-means analysis to actually form the clusters. According to the results of the ANOVA analysis (F (2, 22) = 31.084, $p < 0.001$; F (2, 22) = 28.419, $p < 0.001$; Table 10), the formed clusters were statistically significant. As can be seen in Figure 4, the analyzed countries were classified into three clusters.

Table 9. Principal components for EU countries (rotated component matrix).

Initial Variables	PC1	PC2
Labor productivity	**0.941**	0.151
GDP per capita	**0.906**	0.316
Employment in services	**0.887**	0.262
Human Development Index	**0.881**	0.354
Employment in KIA	**0.845**	0.385
Europe 2020 Competitiveness Index	**0.687**	0.584
Employment in agriculture	**−0.667**	−0.542
Involuntary part-time employment	−0.202	**−0.832**
In-work poverty rate	−0.228	**−0.816**
Vulnerable employment	−0.165	**−0.794**
Inclusive Development Index	0.432	**0.763**
Employment rate	0.327	**0.736**
Total poverty rate	−0.320	**−0.726**
Compensation of employees	0.442	**0.614**

Note: extraction method: principal component analysis; rotation method: Varimax with Kaiser normalization; rotation converged in three iterations.

Table 10. The results of the cluster analysis: final cluster centers and ANOVA.

	Final Cluster Centers			ANOVA					
	Cluster			Cluster		Error		*F*	Significance
	1	2	3	Mean Square	df	Mean Square	df		
PC1	0.913	0.108	−0.966	8.863	2	0.285	22	31.084	0.000
PC2	0.501	−1.657	0.328	8.651	2	0.304	22	28.419	0.000

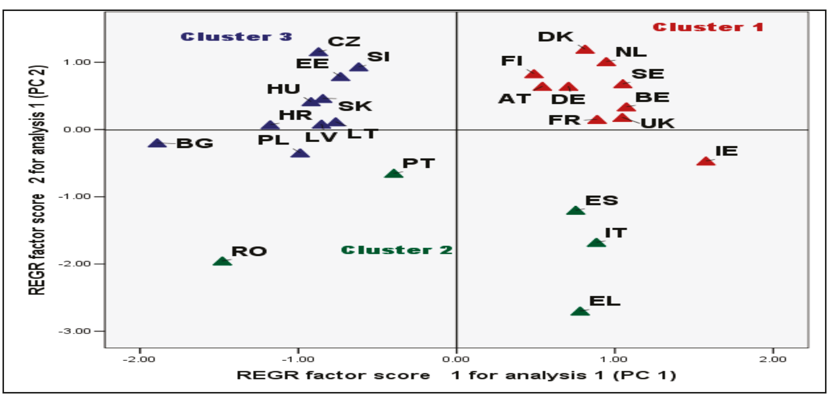

Figure 4. EU cluster analysis results.

Cluster 1 was positively correlated with factor 1 (PC1), but also with factor 2 (PC2) (0.913 and 0.501, respectively, Table 10). All ten countries included in this group (Austria, Belgium, Germany, Denmark, Finland, France, Ireland, Netherlands, Sweden, and United Kingdom) are old EU member states with the highest level of economic, human, and inclusive development. In the case of these countries, Europe 2020 Competitiveness Index level and labor productivity are also very high (Figures 5 and 6). As regards the employment indicators, it is noted that this cluster has the highest level of employment rate (73.83%).

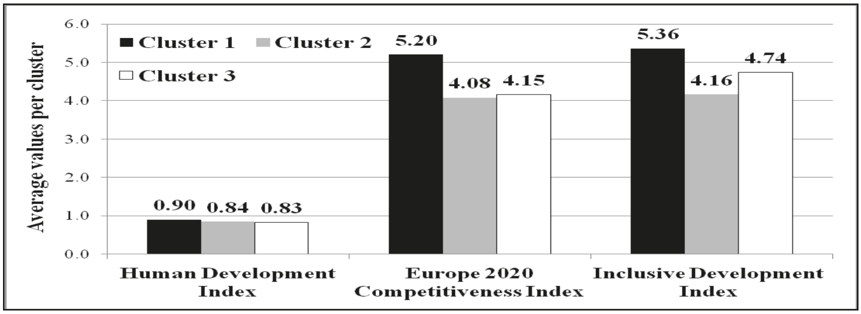

Figure 5. Inclusive and sustainable development and competitiveness. Source: own calculations based on References [36,58,60].

Over 77% of jobs are created in services, and 39.5% in knowledge-intensive activities (KIA), demonstrating a high role of knowledge in these economies (Figure 6). Employment in agriculture, vulnerable employment, involuntary part-employment, and poverty rate (working poverty and overall poverty) recorded the lowest level compared to the other clusters (Figure 7). Countries from this cluster (except Ireland) were placed in the first quadrant (Figure 4). Ireland was placed in the fourth quadrant, but close to PC1, because employment in agriculture, vulnerable employment, and involuntary part-time employment are higher compared to the average of this cluster, but lower than in other clusters.

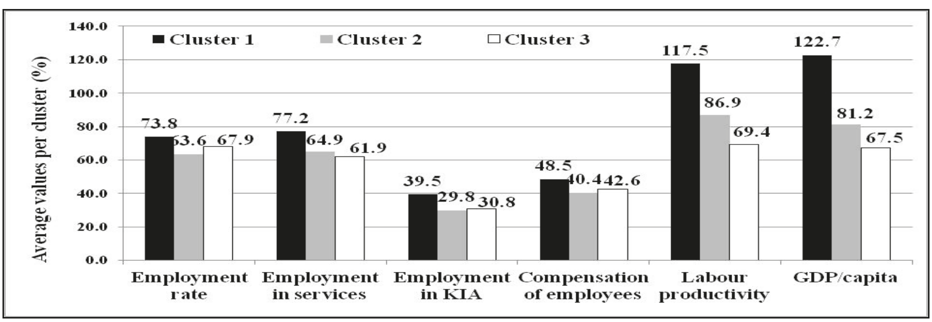

Figure 6. Productive employment and economic development (average values per cluster). Source: own calculations based on Reference [21].

Cluster 2 included five countries (Greece, Italy, Spain, Portugal, and Romania) with the highest working poverty rate, vulnerable employment, employment in agriculture, and involuntary part-time employment (Figure 6). This cluster was strongly negatively correlated with factor 2 (−1.657, Table 10). From the perspective of IDI and Europe 2020 Competitiveness Index, this cluster was the lowest. Within this cluster, the countries showed high heterogeneity. The southern countries (Italy, Spain, and Greece) are situated in the fourth quadrant (Figure 4) close to the negative sense of PC2, achieving both a higher level of economic performance (GDP/capita, labor productivity) and a higher level of deficit in productive employment compared with the average of this cluster. Greece is in first place in EU-28 in terms of involuntary part-time employment (60.29%), in second place in terms of vulnerable employment (28.16%) and working poverty (13.71%), and in third place as regards poverty rate (21.25%; Bulgaria is in second place). Also, this country achieved the worst performance in IDI. Portugal is situated very close to PC1 in a negative sense and tends to be closer to cluster 3. This means that economic development, labor productivity, and employment in services are more reduced than in Italy, Spain, and Greece. Romania's position in the third quadrant and outside the "correlation circle" (Figure 4) is due, on the one hand, to the highest values of indicators which reflect deficits in productive employment and poverty, and, on the other hand, to the lowest values of indicators which reflect productive employment and inclusive and sustainable development, compared with the peer countries in the cluster. Thus, during the 2007–2016 period, Romania was EU-28's leader in terms of poverty rate (23.59%), in-work poverty rate (18.4%), vulnerable employment (30.88%), and employment in agriculture (29.24%). This country was ranked last in EU-28 in terms of employment in services (41.54%), employment in KIA (20.8%), compensation of employees (as a percentage of GDP), and Europe 2020 Competitiveness Index (3.64). Our results show that Romania is confronted with critical challenges in terms of productive employment and its impact on inclusive and sustainable development, taking into consideration that it is ranked last in both cluster 2 and in the EU countries.

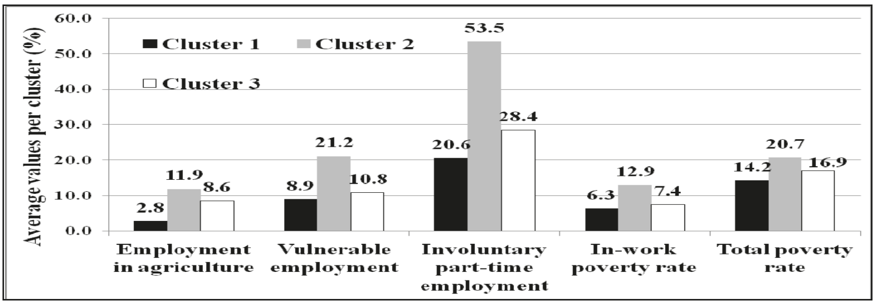

Figure 7. Deficit in productive employment and poverty (average values per cluster). Source: own calculations based on Reference [21].

Cluster 3, which consisted of the Baltic states and some CEE States (Estonia, Lithuania, Latvia, Poland, Czech Republic, Hungary, Slovenia, Slovakia, Croatia, and Bulgaria), was very far from PC1 (−0.966). Thus, some of the indicators such as labor productivity, economic and human development, and employment in services had the lowest values. A low level of economic performance can be observed. The GDP/capita average was only 54.9% of the GDP/capita realized by the countries from cluster 1 and labor productivity was 59.1%. Within this cluster, the countries showed some heterogeneity. Bulgaria and Poland were situated in the third quadrant (Figure 4) because, in these countries, employment in agriculture, compensation of employees, and poverty rate were higher compared with the average of this cluster. Bulgaria was in last place in EU-28 in terms of human and economic development, and labor productivity, and the next to last as regards Europe 2020 Competitiveness Index (3.75). The Czech Republic recorded, during the 2007–2016 period, the lowest in-work poverty rate in EU-28, which can be explained by the highly distributive effects of its welfare system [17,22]. Our results (Figures 5 and 6) show that countries enrolled in this cluster had a lower level of deficit in productive employment, and a lower level of inclusive development and competitiveness than cluster 2, but higher than cluster 1. Thus, cluster 2 was ranked second in terms of productive employment for inclusive and sustainable development.

In the light of these results, it was proven that there are common features and differences between EU member states based on their interrelationship among productive employment, and inclusive and sustainable development; thus, Hypothesis H5 is confirmed. Therefore, different and specific measures are needed to support the improvement of this interrelationship.

5. Conclusions and Main Implications

One of the real challenges of economies in the current economic and social global environment is to generate high productive employment in order to achieve inclusive and sustainable development. In this context, this paper highlighted the main characteristics and mechanisms of productive employment, focusing on the interrelationships among productive employment, and inclusive and sustainable development in the EU countries, during the recent economic crisis and recovery period (2007–2016). Moreover, it is essential to assess productive employment and to identify key opportunities and barriers in order to create productive employment, taking into account that productive employment can be a driving force for reducing gaps between the EU countries in order for these to really integrate into the European Union [8].

The hypotheses in the study were successfully supported by empirical data. The research results showed that economic growth in some EU countries (countries in clusters 2 and 3) should be more sustained and inclusive, and sufficiently employment intensive, such that more job opportunities for a larger workforce are created, and workers, especially those who are poor, benefit from improvements in standards of living [16]. Thus, an important challenge for policy-makers is to mix pro-growth and pro-poor policies [32]. As WEF report [60] (p. 6) states, "a new growth model that places people and living standards at the center of national economic policy and international economic integration is required to transform inclusive growth from aspiration into action in the Fourth Industrial Revolution".

The results of the correlation and regression analysis reflected, on the one hand, the positive influence of labor productivity on inclusive and sustainable development (expressed by GDP/capita, HDI, IDI and Europe 2020 Competitiveness Index), and, on the other hand, the positive influence of the level of employment in services and of employment in knowledge-intensive activities on labor productivity. Also, the results showed that, in the EU countries during the period analyzed, inclusive development was negatively influenced by working poverty (as a deficit in productive employment), and that vulnerable employment and precarious employment were important drivers for a high level of working poverty. Thus, the results showed that gaps in the level of development can be explained by the levels and characteristics of productive employment and that there are large cross-country differences in terms of the interlink between productive employment and inclusive and sustainable development, which emphasizes the need to take specific actions to translate unproductive employment into productive employment.

Results of the PCA and cluster analysis, for the 2007–2016 period, emphasized that the highly developed European countries proved to be more homogeneous in terms of the interrelationship between productive employment, and inclusive and sustainable development, as they were enrolled in the same cluster (cluster 1). On the contrary, European countries with medium and low levels of development, mostly new member states, recorded different results, divided into two clusters. Southern countries (Greece, Italy, and Spain), together with Portugal and Romania, were grouped in the most unproductive cluster (cluster 2) characterized by the highest working poverty, vulnerable employment, employment in agriculture, and involuntary part-time employment, with negative consequences on inclusive and sustainable development.

These findings reflect, on the one hand, the need to accelerate labor productivity growth based on productive structural transformation, characterized by a shift from low-productivity sectors to high-productivity sectors (especially in the countries in cluster 2 and 3). If the European countries, where the agricultural sector still generates significant jobs (Romania, 29.2% of total employment; Bulgaria, 19.2%; Poland, 12.6%; Croatia, 11.7%; Greece, 11.5%), are aware of the potential of the agriculture sector and they act through strategic investments in this sector, agricultural jobs could be more productive; consequently, gains in productivity can raise incomes to a level that enables agricultural workers to escape the poverty trap. On the other hand, it is essential that poor workers significantly benefit from the gains in labor productivity.

Moreover, policies for prematurely deindustrialized countries and for those with a high share of employment in the agricultural sector should target a substantial subsidy for traditional agriculture, focusing on the ecological component of sustainable development. Agricultural jobs should become more productive, but also better paid. Furthermore, these sectoral changes should be accompanied by similar changes from vulnerable employment to wage and salaried employment, having positive consequences on the share of compensation for employees in total income, and an implicit effect on working poverty reduction.

The findings of this research can be useful for policy-makers in order to formulate policies that support the improvement in productive employment within a framework of inclusive and sustainable development.

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sustainability

Article

Sustainability-Related Implications of Competitive Advantages in Agricultural Value Chains: Evidence from Central Asia—China Trade and Investment

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Abstract: More stable value chains in agriculture allow countries to take the best advantage of their factor endowments and thus achieve the UN Sustainable Development Goal on ending hunger. It is, however, difficult to interpret such advantages properly due to the multivariate effects of natural, technological, and economic variables on agricultural output and food supply. The authors attempt to tackle this challenge by developing the approach to the identification of competitive advantages and matching them with the production capabilities of agricultural sectors in Central Asia. The application of Revealed Comparative Advantage (RCA), Relative Trade Advantage (RTA), Lafay Competitive Advantage (LI), and Domestic Resource Costs (DRC) indexes to the array of 37 products results in the revealing of comparative, trade, competitive, and production advantages of five Central Asian economies for labor-intensive horticultural products and grains. Capital and technology-intensive sectors of animal husbandry and food processing are recognized as low competitive. Taking Central Asia–China collaboration as a model, the authors elaborate policy measures aimed at support, promotion, or establishment of competitive advantages. The application of the measures facilitates the concentration of the resources toward competitive and conditionally competitive products, allows to protect fragile advantages in marginally competitive sectors, and contributes to the overall improvement of stakeholders' performance across agricultural value chains in the region.

Keywords: agriculture; Central Asia; food security; sustainability; value chain

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1. Introduction

With the dissolution of the Soviet Union in 1991, five countries of Central Asia (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan) along with other Soviet republics gained independence and entered a period of transition from planned to market-based economies [1]. In the early 1990s, the transition was particularly painful for the newly independent states due to the sharp economic decline, inflation, and disruption of production and trade ties with Russia and other territories of the former Soviet Union [2]. In no time, previously closed markets became open to global trade, but the countries of Central Asia were not able to immediately convert openness to sufficient gains due to the total lack of competitiveness [3]. Market principles called for the establishment of qualitatively new types of linkages and value chains based on competitive advantages rather than command planning and administrated supply networks. Underdeveloped transport infrastructure oriented on central parts of Russia (Soviet heritage), as well as landlockedness and remoteness from major economic centers and trade hubs, contributed to the degradation of the competitiveness of the Central Asian countries [2] and increased economic and social instability in the entire region.

Agriculture was among those sectors where production capabilities, trade links, and competitive advantages were cut in the most severe way. Before the start of the market transition, agriculture had been one of the major sectors in Central Asian economies and contributed up to 45% of their GDPs and provided employment to almost 50% of the labor force [4]. Despite the launch of agricultural and land reforms in 1992–1993, the performance of the agricultural sector has been rather weak across the region [5]. The volume of production of animal products (various kinds of meat and meat products), and some staple cereals (wheat) has fallen significantly. Apart from the general economic decline in Central Asian countries during the 1990s, the key reasons for such a bad performance are the low competitiveness of the agricultural sector and distortion of competitive advantages for the gain of the command economy. In Soviet times, each country of Central Asia specialized in the production of particular agricultural products according to the general plan (wheat and other grains in Kazakhstan, corn and lamb in Kyrgyzstan, cotton and fruits in Tajikistan, Uzbekistan, and Turkmenistan) [6]. Command allocation indeed took into account available natural resources and capabilities of particular countries but created mono-specialization and did not allow diversification, which negatively affected both the competitiveness positions and flexibility of Central Asian economies when transitioning to the market-based principles of competition.

Along with the structural barriers, the development of competitive advantages in agriculture has been hindered by poor land management [7], land degradation and salinization [8], irrational water use [9], desertification and reduction of the areas under crops in the irrigated lands [10], and climate change effects such as higher temperatures, changing precipitation, and river runoff [11]. Those factors have led to low productivity levels across the entire agricultural sector. As vast territories are regularly used for extensive livestock husbandry, only a small portion of agricultural land can be used for crop production and horticulture [12]. The upshot is that agriculture has become less important as a source of livelihood for many people, agricultural revenues are partially replaced by remittances from labor migrants [13], while the continuing decline in agricultural production aggravates the standards of living and food security problems in rural areas, where over 90% of the population is now defined as poor and food insecure [14].

In recent decades, the food insecurity problem has emerged globally with Asia being one of the regions most critical to meeting the challenge of sustainable food supply [15]. Establishing food security, ensuring sustainable food production systems, ending hunger, and providing access by all people to safe, nutritious, and sufficient food are the targets of the United Nations Sustainable Development Goals to be achieved by 2030 [16]. As a part of the global community, the countries of Central Asia are also committed to achieving the sustainable development goals on the elimination of hunger and improvement of food security along the four dimensions of availability, access, stability, and utilization as prescribed by the Food and Agriculture Organization of the United Nations (FAO) [17]. These efforts resulted in a substantial improvement of food security in the region compared to the 1990s. In particular, the average prevalence of undernourishment decreased from 11% in the early 2000s to 6% in 2017 [18]. Nevertheless, significant levels of poverty along with poor availability and low accessibility of food staples [19] still keep the prevalence of undernourishment an issue of concern in Uzbekistan (7.4%), Kyrgyzstan (6.5%), and Turkmenistan (5.5%) [18]. Among the major threats to sustainable food security in Central Asia, Schroeder and Meyers [20] pointed out inadequate micronutrient intake, growing obesity rates, and high dependence on food imports which posed a risk to sufficient availability and economic accessibility of food products on the domestic markets. In recent years, FAO [18] has reported an increasing prevalence of severe food insecurity (PoSFI) in the region from 1.7% in 2015 to 3.5% in 2017. The PoSFI implies a probability of people having been unable to access nutritious and diverse food and having been forced to reduce the quantities of food eaten as a result of lack of money or other resources [21] and thus demonstrates that the food insecurity problem in Central Asia is primarily associated with economic aspects of sustainable development of the agricultural sector. To date, indeed, the agricultural sector has lost a dominating role in Central Asian economies amid the emergence of oil and gas and other resource-extraction industries. Nevertheless, it still contributes 23.3% of the GDP in Tajikistan, 20.8% in Kyrgyzstan, and 18.5% in Uzbekistan (compared to over 50% in the 1990s), but in hydrocarbon and gas-abundant Kazakhstan and Turkmenistan, its contribution to the GDP is no longer impressive (5.2% and 7.5%, respectively) [22]. For Uzbekistan, Tajikistan, and Kyrgyzstan, agricultural trade remains one of the major sources of export revenues despite the substantial changes in trade patterns and the directions and structure of exports in the past decades.

According to Kurmanalieva and Parpiev [2], one of the most prominent features of the Central Asian trade since the recovery of the independence in 1991 has been its drastic reorientation from the former Soviet republics to the rest of the world, specifically, to Asia. Since the mid-1990s, the governments in Central Asia have been increasingly undertaking policy measures and activities with the specific goals of trade facilitation and improvement of connectivity with China [1], while China itself has been emerging as one of the key trade partners of Central Asia [23]. China has been gradually occupying those niches and gaps on the market which had been created by the disruption of trade and production ties between Central Asia, Russia, and other former Soviet republics. With the launch of the Belt and Road Initiative (BRI), China declared its commitment to improving infrastructural and trade connectivity along with sustainable value chains in Eurasia with Central Asia being a crucial component in the network. While neither agricultural trade nor food security has been specifically outlined among the BRI goals, both themes are of fundamental importance for China. The country has already made substantial contributions to combating rural poverty and food insecurity and improvement of the global stability of food production and supply through innovations, intensification of farming and agricultural productivity, and food safety [24]. In 2019, in its new National Strategy on Food Security, China declared its further commitment to every possible promotion of agricultural trade, active participation in global food security, and establishment of healthy and sustainable development of food value chains worldwide [25].

Between 2000 and 2018, interregional agricultural trade in Central Asia has been declining while international trade has been experiencing a fast growth of imports but the sluggish real growth of exports [13]. Exports of cotton, fruits, cereals, and some other products have been gradually reoriented from Russia and the EU to China and other Asian markets. Exports reached $230.1 million in 2018, while imports increased from $27.4 million in 2000 to $553 million in 2018 (Table 1). Agricultural trade balance with China is steadily negative for the countries of Central Asia.

Table 1. Agricultural trade between China and the countries of Central Asia in 2000–2018, $ million.

Countries	Years						
	2000	2005	2010	2015	2016	2017	2018
Import to Central Asia from China							
Kazakhstan	13.367	53.388	133.701	231.527	216.610	313.166	322.672
Kyrgyzstan	2.758	21.471	125.332	154.439	101.042	47.277	127.627
Tajikistan	0.248	2.243	13.013	16.675	12.197	21.144	15.153
Turkmenistan	1.690	3.041	5.375	11.677	16.914	9.918	8.023
Uzbekistan	9.381	14.735	29.624	62.527	39.893	53.594	79.702
Total imports	27.444	94.878	307.045	476.845	386.656	445.099	553.177
Export from Central Asia to China							
Kazakhstan	0.105	0.926	12.271	100.797	120.626	175.610	184.477
Kyrgyzstan	0.495	0.067	1.159	4.572	3.108	4.603	2.997
Tajikistan	0.000	0.000	0.312	0.622	0.305	0.366	0.727
Turkmenistan	0.000	0.000	0.000	0.156	0.078	1.119	1.244
Uzbekistan	0.069	0.218	0.594	22.019	27.906	23.007	40.651
Total exports	0.669	1.211	14.336	129.053	152.023	204.705	230.096

Table 1. *Cont.*

Countries	Years 2000	2005	2010	2015	2016	2017	2018
	Central Asia's trade deficit with China						
Kazakhstan	13.262	52.462	121.430	130.730	95.984	137.556	138.195
Kyrgyzstan	2.263	21.404	124.173	149.867	97.934	42.674	124.630
Tajikistan	0.248	2.243	12.701	16.053	11.892	20.778	14.426
Turkmenistan	1.690	3.041	5.375	11.521	16.836	8.799	6.779
Uzbekistan	9.312	14.517	29.030	39.621	11.987	30.587	39.051
Total trade balance	26.775	93.667	292.709	347.792	234.633	240.394	323.081

Source: Authors' development based on [26].

Low self-sufficiency in staple foods is a challenge for the countries of Central Asia [27]. High reliance on imports hinders the development of disintegrated value chains and heavily subsidized agricultural sector and imposes a threat to sustainable availability and accessibility of food products on the market. Both households and producers experience severe effects of food prices fluctuations as large percentages of households' and state budgets' incomes are spent on food imports [11]. Peyrouse [28] reports that in Tajikistan and Uzbekistan, people spend 80% of their household incomes on food. This corresponds to the fact of Tajikistan's lowest level of food self-sufficiency in the region (31%) and indicates that Central Asian markets are particularly exposed to the instability of the global food market. In response to the increasing dependence on agricultural imports (not only with China but with Russia and the EU as well) and growing food insecurity and poverty levels, some countries of Central Asia, specifically, Kazakhstan and to a certain degree Turkmenistan and Kyrgyzstan, adopted food self-sufficiency policies [29]. For low diversified industries with few competitive products, however, self-sufficiency policy rarely works out as a driver of competitiveness as it diverts resources to lower-efficiency sectors and thus triggers inappropriate use of the country's advantages. Given, first, the emergence of the food insecurity problem in Central Asia, second, food self-sufficiency policies of Central Asian governments, and third, the growing involvement of Central Asian countries in global agricultural market and trade with China, it is imperative to study the most appropriate use of various resources and advantages the countries possess.

With an increased awareness of the link between sustainable development of agricultural production, food security, and competitive advantages in trade [24], reliance on research has become more critical. One branch of studies analyzed trends in the agricultural sector in Central Asia in general and individually in certain countries. Schroeder and Meyers [20] conducted a comprehensive analysis of agricultural production and trade, constraints and bottlenecks in agricultural productivity growth, as well as the policies that may be implemented to shape sustainable food security and reduce malnutrition. Akter et al. [30] synthesized emerging issues and challenges that confronted food sector in Central Asia and called for the identification of competitive advantages, elaboration of development strategies, and setting priorities for future food, agriculture, and natural resource policy agendas for sustainable development of the agricultural sector and rural areas. There have been many studies that drifted away from food production and focused specifically on various dimensions of food security across the region of Central Asia. Thus, Babu and Pinstrup-Andersen [19] identified major challenges to food security across Central Asian countries and suggested the measures and policy transformations to facilitate economic reforms, reduce poverty, increase food security, and ensure sustainable use of natural resources. Akramov [31] addressed the impact of global food prices on the domestic market and policy responses taken by national governments to stabilize food markets.

There is an array of studies that address economic and trade linkages between Central Asia and China, but the majority of them pay inadequate attention to agricultural trade. Bird et al. [32] and Kokushkina and Soloshcheva [33] assessed the participation of Central Asian countries in the BRI based on the revealed comparative advantage and other indicators with a major focus on trade in resources and raw materials. Vakulchuk and Overland [34] analyzed the present state of relations between the countries of Central Asia and China and systematized the BRI's perceptions on the part of various stakeholders, including local rural communities and farmers, and found that many value chain actors remained weakly connected to Central Asia-China value chains. Another shortcoming is that those few studies related to both the BRI and agricultural collaboration in Central Asia concentrate on individual countries. Carter [35] reviewed the patterns of China's recent trade and investment policies in Central Asia in the cases of Kazakhstan and Tajikistan, Bitabarova [36] conducted similar analysis for Kazakhstan, Babu and Reidhead [37] provided insights into poverty, food insecurity, and malnutrition in Kyrgyzstan, while Asadov [27] searched for possible solutions to critical dependence on food imports and staple food self-insufficiency in Tajikistan.

A specific fragility of the advantages in Central Asia's agriculture calls for a comprehensive analysis on the regional level. The fragility and erosion of the advantages due to a variety of natural, technological, and economic factors bring instability to the entire value chain in agriculture. Reyer et al. [11] studied possible climate change impacts on the agricultural sector in Central Asia and found extreme vulnerability of competitive advantages to even slightest changes in precipitation, rainfall patterns, and heat extremes. Adding value allows to increase the share of processed higher-value agricultural products in export, as well as to improve both self-sufficiency and sustainability through growing farmers' income and more employment opportunities in agriculture [38], but the sustainability of agricultural value chains in Central Asia, nevertheless, remains scantily explored. Discretely, some references to the relevance of sustainable value chains for Central Asia can be found in the studies of Bloch [39], Rakhimov [40], Turaeva and Hornidge [41], and Pomfret [1,42]. Pirmatov et al. [38] attempted to conduct a comprehensive analysis of value-added chains in the production of cotton, wheat, rice, and fruit and found the unrealized potential for storing, freezing, processing, and packaging of even the most competitive products. The study of Pirmatov et al. [38] considered the socio-economic role of value-added agriculture for Central Asian countries but did not link the performance and sustainability of value chains with the exploitation of competitive advantages of particular countries of the region in food production and trade. Similarly, Rillo and Nugroho [43] studied the challenges to the development of integrated value chains without proper previous investigation of competitive advantages in agricultural sectors across the countries of Central Asia. Egilmez [44] covered different regions of the world and scarcely focused on Central Asia, while Hanf and Gadalyuk [45] conducted a detailed analysis of value chains in Kyrgyzstan but limited the study to the sector of small-scale farming.

Summarizing the above, the following gaps in Central Asia-China agricultural trade and the value chains agenda can be identified:

- The research of competitive advantages in agriculture is very scarce for Central Asia. Most commonly, the studies are focused on climate, soil, and irrigation as the major determinants of agricultural productivity in the region, but insufficiently explore economic and trade patterns of the competitiveness.
- Many studies examine revealed comparative advantage as a decisive parameter to identify the competitiveness of agricultural products on the global market. Consideration of other types of strengths (trade, competitiveness, production, among others) could benefit the establishment of truly sustainable advantage in agriculture in the long run.
- Despite the geographical proximity of the five countries of the region, they are rather different in terms of the conditions of agricultural production. Currently, among the countries of Central Asia, Kazakhstan's economy seems the best studied one in terms of comparative advantages while for other countries (particularly, Turkmenistan and Uzbekistan) few studies address the advantages in agricultural value chains.
- In the China–Central Asia agenda, two types of studies prevail: Broad overviews of trade and economic policies (transformation period in Central Asia and China's trade openness policy, most recently, the BRI) and the analysis of trade in resources and raw materials. To the best of the authors' knowledge, there are no comprehensive studies of agricultural trade between China and the countries of Central Asia from the perspectives of competitive advantages and sustainable development of value chains.

In this paper, the authors attempt to bridge these gaps by developing the approach to the identification of existing and potential competitive advantages in the spheres of agricultural production and food supply across the region of Central Asia. In the case of Central Asia-China trade in food and agricultural products, the study aims to elaborate the solutions to the problems of low competitiveness of agricultural sectors and in such a way to contribute to the improvement of the sustainability of agricultural value chains in the macro-region of Eurasia.

The remainder of this paper is divided into four sections. In Section 2, the authors review the most commonly used as well as the most appropriate approaches to the identification of competitive advantages in agricultural value chains. Based on this review, the five-stage methodology for the identification of the advantages is established. In Section 3, the authors present the results of the application of the methodology to the array of major food and agricultural products in Central Asia's export. In Section 4, the findings are discussed through the lens of the correspondence between the competitiveness of Central Asia's agricultural export and the prospects of food demand in China and China's agricultural investment in the region. The discussion concludes with the elaboration of policy measures for the promotion of the revealed advantages and the improvement of the sustainability of agricultural value chains.

2. Materials and Methods

The study is performed in the case of the five countries of Central Asia (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan) and China in 2000–2018 (Figure 1).

Figure 1. Countries of Central Asia and China. Source: Authors' modification of [46].

The data are obtained from the United Nations Conference on Trade and Development (UNCTAD) [26]. SITC Commodity classification is used. The total volume of agricultural trade in both exports and imports is generalized as SITC "All food items" (SITC 0 + 1 + 22 + 4). The array of the products is built along 37 positions and include major food and agricultural commodities traded between China and the countries of Central Asia. To assess the advantages of the Central Asian economies in agricultural trade, the study employs the five-stage approach.

2.1. Stage 1: Balassa Index

Classical trade theory assumes that the pattern of international trade is determined by comparative advantage [47]. In the attempts to measure the advantages, the scholars have used various techniques, including multivariate data analysis (factor analysis, cluster analysis, and structural equation modeling), trade data on exports and imports [48,49], and descriptive approaches [50,51]. One of the commonly accepted methods to identify the advantages of a country on the global market is the Balassa index of revealed comparative advantage (RCA) [52]. It has been used by many researchers for the identification of the changes in comparative advantages worldwide [53–55]. Porter [56] implemented the RCA index to identify strong sectoral clusters in international trade. Konstantakopoulou and Skintzi [57] used it to discover comparative advantages of the EU countries by sectors and by major product categories, Amiti [58] analyzed the specialization patterns in Europe. In the case of China, Hinloopen and van Marrewijk [59] analyzed the dynamics of comparative advantage as measured by export shares, Chun [60] investigated comparative advantage by studying the correlations between the cost of labor and foreign trade, Shuai and Wang [61] made an empirical analysis of the comparative advantages and complementarity of agricultural trade, while He [62] modified RCA index to the study of the dynamics of agricultural trade patterns.

There are also abundant studies of Central Asia's comparative advantages. One of the earliest and most comprehensive ones is that by Lücke and Rothert [63] who identified the advantages of Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan based on the information about factor prices and transport costs, historical production patterns, and trends in the geographical and product composition of Central Asian external and interregional trade. The study, however, aimed at the suggestion of broad guidelines for the identification of potentially competitive export sectors rather than focused on the determination of comparative advantages at the industry or product level. In the case of Kazakhstan's trade, Bozduman and Erkan [64] analyzed the competitiveness of export products on a sectoral basis and found that the country was competitive in export of hydrocarbons, ores, and other raw material intensive product groups, but excluded agricultural trade from their analysis. Falkowski [65] also excluded agricultural products from the study and approached to the investigation of long-term comparative advantages of Kazakhstan and Kyrgyzstan as the members of the Eurasian Economic Union (EAEU) from a perspective of the Organization for Economic Cooperation and Development (OECD) classification of manufacturing industries based on their technology intensity.

To address the existing shortcomings, at the first stage, the authors employ the Balassa method to reveal the comparative advantage of Central Asian countries in trade in agricultural products:

$$RCA = \frac{\frac{X_{ij}}{X_{it}}}{\frac{X_{nj}}{X_{nt}}} = \frac{\frac{X_{ij}}{X_{nj}}}{\frac{X_{it}}{X_{nt}}} \tag{1}$$

where RCA = revealed comparative advantage; X = export; i = country; j = product group (domestic market); t = product group (international market); n = group of countries.

According to the Balassa method, a country i specializes in the export of a product j if the market share of a product j is above average or, equivalently, if the weight of a product j in the total export of a country i is higher than the weight of a product j in the export of the reference area [66]. Stated differently, $RCA_{ij} > 1$ means a country i enjoys a comparative advantage in trade in a product j, while $RCA_{ij} < 1$ means a comparative disadvantage.

When applying the Balassa index to the measuring of the competitiveness of the products, industries, or countries, a difference between comparative advantage and competitiveness must be considered. The OECD [67] defines competitiveness as an economy's ability to compete fairly and successfully in international goods and services markets, which, as a result, leads to a steady rise in the living standards in the long term. According to Dunmore [68], comparative advantage is a statement about international specialization and trade patterns that would arise in an undistorted world based on the differences in relative efficiencies between countries in the absence of trade. Competitiveness, on the contrary, is a characteristic of a country on the real global market distorted by various government policies. Dynamic character of competitive advantages under the conditions of an open economy inversely to comparative advantages is stressed by Weresa [69], Carbaugh [70], Collignon and Esposito [71], and Fagerberg [72].

Accordingly, the measurement of competitiveness should include the assessment of the dynamics of comparative advantages influenced by trade policies. Due to the difference between comparative and competitive advantages, the Balassa index is not that effective in the identification of competitive positions of particular products, since it allows to identify revealed comparative advantages rather than to determine the underlying sources of such advantages [66]. Siggel [73], Costinot et al. [74], and Hinloopen and van Marrewijk [75] point out that although the Balassa method allows detecting the advantage of a country in foreign trade as compared to other economies and the world as a whole, it fails to reveal the reasons of such advantage. It does not let divide comparative advantages on natural (for example, increased competitiveness due to technological innovations or improved efficiency) and acquired ones (for instance, state subsidies or alike distorting administrative measures). Understanding the sources of comparative advantages is crucial for such sectors as agricultural production, where government interventions commonly distort market patterns and affect competitiveness. Specifically, a government may provide support for domestic agricultural producers and exporters, subsidize export, increase or decrease customs tariffs, and employ non-tariff regulations to support the competitiveness of particular agricultural products on the external market [76]. In such cases, RCA shows an advantage, but actual competitiveness is distorted [77].

In the region of Central Asia, the employment of RCA in the measurement of competitiveness results in a very rough picture of the advantages due to the following reasons. First, the static nature of the index does not allow us to consider market disturbances and react to the changes in the equilibrium in the long run [77]. In the case of Central Asian economies which are still in a state of transition from distorted (during the Soviet times) and fluctuant (in the 1990s and 2000s) economic environments, low flexibility of the index is a shortcoming. Second, RCA can be inconsistent or misleading for the countries of the region as for smaller economies it demonstrates stronger advantages than there really are [78,79].

2.2. Stage 2: Vollrath Index

Due to the above shortcomings of the Balassa method, at the second stage, the authors check RCA results by measuring relative trade advantages for the same array of 37 product groups:

$$RTA = \frac{\frac{X_{ij}}{X_{it}}}{\frac{X_{nj}}{X_{nt}}} - \frac{\frac{M_{ij}}{M_{it}}}{\frac{M_{nj}}{M_{nt}}} \tag{2}$$

where RTA = relative trade advantage; X = export; M = import; i = country; j = product group (domestic market); t = product group (international market); n = group of countries.

The Vollrath index of relative trade advantage is a tool to identify the competitive advantages of the products by measuring their relative portions in trade. It is a comparison of how well a country performs in exporting a particular set of products compared to the total export of all its products [80]. In contrast to RCA, RTA takes account of both exports and imports and thus demonstrates net trade advantages and disadvantages. $RTA_{ij} > 0$ means a country i possesses relative trade advantage in a product j, while $RTA_{ij} < 0$ demonstrates relative trade disadvantage. After the identification of product groups j for which $RTA_{ij} > 0$, the results are applied upon previously calculated RCAs, two sets are compared, and the matches between the two types of advantage are identified. The use of two indexes for the same dataset reduces the risk of random error.

The Vollrath index was used by Rusali and Gavrilescu [81] in discovering competitive advantages and disadvantages in Romania’s agricultural trade, by Drabik and Bartova [82] in the study of the

Slovak food trade specialization pattern, and by Carraresi and Banterle [83] in the assessment of the agricultural competitive performance in the EU countries. Similar to RCA, when measuring the competitiveness of agricultural products in an export portfolio of a country through RTA, it is crucial to examine the extent to which trade advantages are consistent with competitiveness [84]. Ballance et al. [85] discovered that results on the consistency of the RCA and RTA indexes are mixed. Khai et al. [86] examined coherence between the RCA and RTA indexes and concluded that despite the high consistency, the competitiveness of some product groups remained unclear. Ferto and Hubbard [87] tested a coherence between RTA and competitiveness in the cases of agricultural exports in Europe and found that the two indexes were not consistent in cardinal and ordinal measures.

2.3. Stage 3: Lafay Index

There have been many attempts to increase the consistency between various measures and improve the relevance of the competitiveness analysis. Since both RCA and RTA are structural, it is important to eliminate the influence of cyclical factors [88]. One of the most promising methods to do that is the Lafay index (LI):

$$LI_{ij} = \frac{1000}{Y_i} \times 2\frac{X_{ij} \times M_i - X_i \times M_{ij}}{X_i + M_i} \tag{3}$$

where LI = Lafay index; X = export; M = import; i = country; j = product group.

The Lafay index allows to test both RCA and RTA indicators by considering the difference between each product's normalized trade balance and the overall normalized trade balance [89]. It also weights each product's contribution according to the particular importance in trade. $LI_{ij} > 0$ means a country i possesses a competitive advantage in a product j, otherwise, there is a disadvantage. LI captures intra-industry flows by using both the exports and imports variables and controlling the distortions due to the macroeconomic factors with the GDP variable [90]. For the purpose of this study, it is important that LI does not take into account world variables [47], which is crucial in the establishment of a reliable picture of competitive advantages for smaller economies.

So far, the three-indexes approach has not been widely applied in the literature. Ishchukova [91] and Benesova et al. [92] employed consecutive matching of RCA, RTA, and LI indexes to discover comparative advantages of agricultural exports and distinguishing competitive export products based on the parameters of the amount of foreign exchange, comparative advantage, and trade balance. Maitah et al. [89] used a similar approach for the analysis of the positions of agricultural producers both in comparison to domestic producers from other sectors and in relation to their foreign competitors. Erokhin and Gao [66] modified the approach by applying the three indexes to the same dataset and calculating Lafay index for the same array of product groups constituting a country's export portfolio, not for separate territories as compared to the earlier studies.

The application of the three-indexes approach to trade in agricultural products has definite limitations coming from the very nature of agricultural production. As it has been demonstrated by Ishchukova [91], Maitah et al. [89], Ishchukova and Smutka [93,94], and Erokhin and Gao [66], the three-indexes approach allows to check advantages and model policy responses on the potential strengthening of the advantages or evening out the disadvantages. Theoretically, the most obvious response is to reallocate the resources in such a manner as to increase the production and export of those products in which a country enjoys an advantage. In agriculture, though, simple reallocation is not possible due to the natural limitations (available arable lands and other land resources, quality of land, climate conditions), social and economic factors (rural labor, longer return on investment compared to non-agricultural sectors), time (cycles in crop and animal production, seasonality, etc.), and technical constraints (irrigation, transportation, storage, processing, other kinds of infrastructures in rural areas). Moreover, a simple abandoning of the production of non-competitive agricultural products may decrease the availability of these products on the domestic market and in such a way impose a threat to food self-sufficiency and food security of a country. In Central Asia, where agricultural production is additionally hampered by hot and dry climate, desertification [95], scarcity of arable lands, salinization and land degradation [96], prevalence of small-scale farming, and low diversification of crops [1], among other factors, an establishment of a sustainable value chain requires the matching of competitive advantages with agricultural production capabilities, i.e., production advantages.

2.4. Stage 4: Domestic Resource Costs Index

Considering the existing limitations to the sustainable development of competitive advantages in agriculture, in this study, the authors supplement the three-indexes method by the domestic resource costs index (DRC):

$$DRC_{ij} = \frac{C_{ij}^{d}}{P_{ij} - C_{ij}^{f}} \tag{4}$$

where DRC = domestic resource cost; C^d = domestic input costs; C^f = foreign input costs; P = price of a unit of the output (undistorted border price measured in foreign exchange); i = country; j = product group.

The domestic resource costs concept originates from the works of Bruno [97], Balassa and Schydlowsky [98], and Banerji and Donges [99]. In the 1970s, it started as an approach to the measurement of real opportunity costs in terms of total domestic resources [97], specifically, primary factors such as labor, capital, and land committed to the production of final product with prices at which these products can be traded internationally with foreign exchange gained or saved [99]. The approach has been further adapted to the evaluation and testing of competitive advantages in agricultural trade. Specifically, Hoang et al. [100] advocated for the use of DRC to address the intrinsic weaknesses of coffee production amid the price fluctuation on the world coffee market and volatile competitive advantages, Yercan and Isikli [101] applied DRC to measure international competitiveness of horticultural products, and Masters and Winter-Nelson [102] demonstrated that the DRC method was biased against agricultural activities that relied heavily on such domestic factors as land and rural labor.

DRC shows the value of the country's resources used to produce one unit of a product j. When $DRC_{ij} < 1$, a country i enjoys an advantage in producing a product j (the smaller the DRC_{ij} the greater the advantage), otherwise, there is a disadvantage in the production [77]. The index is widely used in agricultural trade and policy analysis as it allows to identify efficient production sectors [103]. In this study, an introduction of the DRC index to the model as the fourth criteria allows to match four types of advantages (comparative, trade, competitive, and production) and in such a manner to build a more comprehensive picture of competitive position of a country on the global market and suggest where the policies should be targeted to improve the productivity as a reaction to competitive advantage.

2.5. Stage 5: Competitiveness Ranking

The application of the four indexes results in the identification of the products which demonstrate advantages in all four cases (hereinafter referred to as "competitive"), as well those for which the advantages do not intersect ("non-competitive") and those for which at least one of the parameters shows an advantage ("conditionally competitive" and "marginally competitive" depending on the degree of the production advantage). At stage 5, the products are distributed among the groups according to their competitiveness rankings (Table 2).

When $RCA > 1$, $RTA > 0$, $LI > 0$, and $DRC < 1$, a product j is recognized as competitive (C group) with comparative, trade, competitive, and production advantages. If a product demonstrates an advantage on any of RCA, RTA, or LI indexes and at the same time possesses a production advantage, it is defined as conditionally competitive (CC group). For the products for which $DRC > 1$, an arithmetical average of RCA_{MC+NC}, RTA_{MC+NC}, and LI_{MC+NC} is calculated. Those products for which all three values of RCA_{av}, RTA_{av}, and LI_{av} are below RCA_{MC+NC}, RTA_{MC+NC}, LI_{MC+NC}, respectively, are recognized as non-competitive. The products for which at least one of the values of RCA_{av}, RTA_{av}, and LI_{av} is above

RCA_{MC+NC}, RTA_{MC+NC}, LI_{MC+NC}, respectively, are distributed to the MC group. Based on the identified competitiveness parameters, group-differentiated policy measures are suggested to support, promote, and protect the advantages.

Table 2. Grouping of products on their competitiveness.

Groups	Competitiveness Criteria
Competitive (C)	$RCA_{av} > 1$, $RTA_{av} > 0$, $LI_{av} > 0$, and $DRC_{av} < 1$
Conditionally Competitive (CC)	$RCA_i > 1$, or/and $RTA_i > 0$, or/and $LI_i > 0$, and $DRC_i < 1$
Marginally Competitive (MC)	$RCA_{av} > RCA_{MC+NC}$, $RTA_{av} > RTA_{MC+NC}$, $LI_{av} > LI_{MC+NC}$, and $DRC_{av} > 1$
Non-Competitive (NC)	$RCA_{av} < RCA_{MC+NC}$, $RTA_{av} < RTA_{MC+NC}$, $LI_{av} < LI_{MC+NC}$, and $DRC_{av} > 1$

Note: RCA—revealed comparative advantage, RTA—relative trade advantage, LI—Lafay competitive advantage, DRC—domestic resource cost. Source: Authors' development.

3. Results: Central Asia's Perspective

3.1. Revealed Comparative Advantages

At stage 1, the study reveals the comparative advantages of agricultural exports across 37 product groups. Based on the average RCA values in 2000–2018, the most notable advantages are identified for the crop sector and horticulture. Product groups with the highest competitiveness potential in export include wheat and meslin flour, fruits and nuts, vegetables, and other crop products. Among the countries of Central Asia, only Kyrgyzstan possesses a comparative advantage in livestock products (Table 3).

Table 3. RCA_{av} values for selected agricultural products in Central Asia in 2000–2018.

Products	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Live animals	0.032	2.030	0.042	0.002	0.292
Meat of bovine animals, fresh, chilled or frozen	0.016	0.018	0.000	0.000	0.006
Other meat and edible meat offal	0.036	0.306	0.000	0.010	0.004
Meat, edible meat offal, salted, dried	0.002	0.034	0.000	0.000	0.000
Meat, edible meat offal, prepared, preserved	0.066	0.358	0.000	0.002	0.000
Milk and dairy products	0.104	4.770	0.012	0.000	0.008
Butter and other fats and oils derived from milk	0.218	5.194	0.016	0.004	0.000
Cheese and curd	0.042	2.444	0.008	0.000	0.004
Eggs, eggs' yolk, albumin	0.256	0.136	0.000	0.148	0.288
Fish, fresh, chilled or frozen	0.290	0.034	0.020	0.010	0.058
Fish, dried, salted, smoked	0.120	0.050	0.000	0.000	0.002
Crustaceans, mollusks, and aquatic invertebrates	0.000	0.022	0.000	0.014	0.000
Fish and aquatic invertebrates	0.082	0.038	0.162	0.004	0.000
Wheat and meslin	4.890	0.082	0.010	0.010	0.572
Rice	0.284	0.190	1.626	0.002	0.008
Barley	5.222	0.050	0.000	0.000	0.000
Maize	0.004	0.070	0.002	0.000	0.048
Cereals, unmilled	0.452	0.128	0.002	0.000	0.002
Flour (wheat and meslin)	27.332	3.876	3.564	1.510	2.724
Other cereal meals and flour	0.674	0.044	0.050	0.086	0.004
Cereal preparations, flour of fruits or vegetables	0.134	0.506	0.010	0.004	0.052
Vegetables	0.242	9.112	3.296	0.086	6.610
Vegetables, roots, tubers, prepared, preserved	0.016	0.696	1.394	0.012	2.130
Fruits and nuts	0.062	4.736	6.548	1.042	9.312
Fruit, preserved	0.024	0.304	0.478	0.044	1.002
Fruit and vegetable juices	0.032	0.834	5.636	0.008	2.188
Sugar, molasses and honey	0.304	3.598	0.112	0.032	0.028
Sugar confectionery	0.452	0.324	0.044	0.014	0.516
Coffee and coffee substitutes	0.038	0.098	0.010	0.012	0.000
Cocoa	0.006	0.002	0.000	0.000	0.000

Table 3. *Cont*.

Products	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Chocolate	0.220	0.456	0.248	0.030	0.262
Tea and mate	0.158	2.194	0.066	0.024	0.002
Spices	0.002	0.272	0.348	0.382	1.470
Feeding stuff for animals	0.168	0.108	0.002	0.182	0.346
Margarine	0.488	2.938	0.000	0.010	0.008
Edible products and preparations	0.126	0.512	0.022	0.002	0.036
Oilseeds and oleaginous fruits	1.274	0.206	0.738	0.044	0.886

Note: Green cells—product groups with comparative advantage. Source: Authors' calculation based on [26].

3.2. Relative Trade Advantages

At stage 2, the study aims at the identification of those agricultural products for which relative trade advantage is positive and then matching average values of trade and comparative advantages (Table 4).

Table 4. RTA_{av} values for selected agricultural products in Central Asia in 2000–2018.

Products	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Live animals	−0.764	−1.223	1.673	−0.845	−0.394
Meat of bovine animals, fresh, chilled or frozen	−0.499	−0.956	−2.554	−0.391	−0.598
Other meat and edible meat offal	−0.208	−0.591	−1.960	−0.492	−0.492
Meat, edible meat offal, salted, dried	−0.746	−0.443	−1.438	−0.818	−0.694
Meat, edible meat offal, prepared, preserved	−0.552	−0.309	−1.005	−0.738	−0.440
Milk and dairy products	−2.955	1.927	−2.028	−1.118	−0.941
Butter and other fats and oils derived from milk	−1.730	0.770	−2.315	−1.231	−1.329
Cheese and curd	−1.663	−0.301	−1.583	−0.890	−1.226
Eggs, eggs' yolk, albumin	−2.967	−1.609	−0.376	−0.204	−0.845
Fish, fresh, chilled or frozen	1.004	0.098	−2.228	−1.948	−2.380
Fish, dried, salted, smoked	1.291	0.238	−2.392	−1.773	−2.005
Crustaceans, mollusks, and aquatic invertebrates	0.007	−1.224	−3.410	−2.022	−3.538
Fish and aquatic invertebrates	0.019	−1.503	−3.109	−2.118	−3.103
Wheat and meslin	3.438	−0.884	−0.334	0.025	−0.047
Rice	−0.083	−2.361	0.883	−0.444	−0.885
Barley	1.109	−1.330	−0.503	0.117	−0.494
Maize	−1.754	−1.948	−0.991	−0.428	−1.205
Cereals, unmilled	−0.993	0.004	−0.895	0.073	−0.403
Flour (wheat and meslin)	2.291	−0.882	0.649	0.481	0.302
Other cereal meals and flour	0.008	−0.420	0.008	0.365	−0.038
Cereal preparations, flour of fruits or vegetables	0.129	−0.251	0.429	0.522	0.295
Vegetables	0.583	0.529	0.077	1.247	0.038
Vegetables, roots, tubers, prepared, preserved	0.429	0.494	0.012	0.719	0.092
Fruits and nuts	1.530	3.280	1.370	1.009	1.628
Fruit, preserved	0.888	2.425	1.394	0.917	0.944
Fruit and vegetable juices	1.002	1.730	0.641	0.238	0.727
Sugar, molasses and honey	−0.730	1.004	−0.493	−0.371	0.085
Sugar confectionery	−1.628	0.397	−0.648	−1.317	−0.438
Coffee and coffee substitutes	−3.047	−2.092	−3.881	−1.528	−2.225
Cocoa	−1.994	−3.114	−3.202	−2.020	−2.702
Chocolate	−1.703	−2.606	−3.444	−2.418	−2.993
Tea and mate	−2.906	−1.994	−1.820	−0.905	0.066
Spices	−0.839	−0.422	0.553	0.177	0.054
Feeding stuff for animals	0.977	0.575	−1.112	0.883	−0.048
Margarine	0.022	−0.149	−1.284	−0.691	−1.596
Edible products and preparations	0.393	−0.338	−0.404	0.447	−0.330
Oilseeds and oleaginous fruits	1.619	0.792	−0.328	0.303	0.444

Note: Green cells—product groups for which RCA and RTA match; yellow cells—product groups with relative trade advantage. Source: Authors' calculation based on [26].

Comparative and trade advantages overlap largely for crops and horticultural products (fruit, wheat, oilseeds, rice, barley, spices), while do not match in the livestock sector and food processing (particularly, in Kyrgyzstan).

The study also reveals that, in some cases, the countries of Central Asia trade in those agricultural products in which they possess no distinct comparative advantages but only trade ones—aquaculture products in Kazakhstan and Kyrgyzstan, cereal meals and preparations in Turkmenistan and Tajikistan, feeding stuff for animals in Kazakhstan and Turkmenistan, and oilseeds in Uzbekistan and Kyrgyzstan, among others.

3.3. Competitive Advantages

A revealed discrepancy between the advantages attests to the relevance of measuring the competitiveness through several alternative parameters. At stage 3, applying the Lafay index to the established grid of RCA and RTA values, we see that the countries of Central Asia have competitive advantages in labor-intensive horticulture (fresh fruits and nuts) rather than technology-intensive food processing or finance-intensive livestock sector. Even for the production of preserved fruit and fruit and vegetable juices, LI indicators do not fully match previously identified comparative and trade advantages (Table 5).

Table 5. LI_{av} values for selected agricultural products in Central Asia in 2000–2018.

Products	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Live animals	−0.004	−0.332	−0.446	−0.597	−0.835
Meat of bovine animals, fresh, chilled or frozen	0.041	−0.428	−0.259	−0.886	−0.946
Other meat and edible meat offal	0.007	−0.229	−0.303	−0.365	−0.808
Meat, edible meat offal, salted, dried	−0.021	−0.341	−0.296	−0.496	−0.737
Meat, edible meat offal, prepared, preserved	−0.047	−0.120	−0.199	−0.179	−0.961
Milk and dairy products	−0.110	0.117	−1.037	−1.000	−1.054
Butter and other fats and oils derived from milk	−0.124	0.009	−1.204	−1.202	−1.336
Cheese and curd	−0.099	−0.387	−1.231	−1.269	−1.428
Eggs, eggs' yolk, albumin	−0.162	−0.005	−0.306	−1.200	−0.905
Fish, fresh, chilled or frozen	−0.036	−0.206	−1.267	−1.362	−1.201
Fish, dried, salted, smoked	0.008	−0.113	−1.285	−1.401	−1.312
Crustaceans, mollusks, and aquatic invertebrates	−0.237	−1.299	−1.399	−1.003	−1.444
Fish and aquatic invertebrates	−0.244	−1.005	−1.405	−1.554	−1.396
Wheat and meslin	1.774	0.003	−0.775	0.036	−0.057
Rice	−0.302	−0.113	−0.056	−0.402	−0.043
Barley	−0.013	−0.016	−0.062	0.004	−0.128
Maize	−0.014	−0.299	−0.700	−0.078	−0.224
Cereals, unmilled	0.110	−0.004	−0.055	0.012	−0.065
Flour (wheat and meslin)	0.427	0.007	−0.009	−0.045	−0.071
Other cereal meals and flour	0.090	0.015	0.003	0.026	−0.329
Cereal preparations, flour of fruits or vegetables	−0.012	0.012	0.007	0.018	0.012
Vegetables	0.076	−0.045	−0.034	−0.042	−0.056
Vegetables, roots, tubers, prepared, preserved	0.044	−0.071	−0.067	−0.176	−0.112
Fruits and nuts	−0.002	0.481	0.303	0.419	0.665
Fruit, preserved	−0.017	−0.372	−0.044	0.206	0.393
Fruit and vegetable juices	−0.120	−0.279	0.265	−0.385	−0.004
Sugar, molasses and honey	−0.348	0.218	−0.087	−0.204	0.033
Sugar confectionery	−0.401	−0.054	−0.420	−0.123	−0.013
Coffee and coffee substitutes	−0.906	−1.249	−1.164	−0.206	−1.201
Cocoa	−0.997	−1.303	−1.205	−0.443	−1.006
Chocolate	−1.250	−1.442	−1.228	−1.333	−1.350
Tea and mate	−1.089	−0.558	−0.883	−1.004	0.028
Spices	−0.806	−0.366	0.021	−0.008	−0.013
Feeding stuff for animals	0.166	0.013	−0.772	0.056	−0.442
Margarine	−0.709	−0.447	−0.605	−0.175	−0.600
Edible products and preparations	0.010	0.001	−0.843	−0.118	−0.522
Oilseeds and oleaginous fruits	0.229	0.284	−0.674	0.124	0.052

Note: Green cells—product groups for which all three RCA, RTA, and LI match; yellow cells—product groups with competitive advantage. Source: Authors' calculation based on [26].

3.4. Domestic Resource Costs

At stage 4, for all product groups included in the array, the study identifies the value of the resources employed to produce one unit's worth of that agricultural product and in such a way reveals the advantages in production. When imposed on the previously identified comparative, trade, and competitive advantages, the parameter of production advantage allows to ascertain positively competitive (four parameters match) and conditionally competitive food and agricultural products ($DRC < 1$), as well as those products recognized as marginally competitive and non-competitive ($DRC > 1$) (Table 6).

Table 6. DRC_{av} values for selected agricultural products in Central Asia in 2000–2018.

Products	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Live animals	1.207	1.173	1.377	1.190	1.032
Meat of bovine animals, fresh, chilled or frozen	0.826	0.331	1.050	1.114	1.125
Other meat and edible meat offal	0.772	0.305	1.195	1.209	1.153
Meat, edible meat offal, salted, dried	0.910	0.343	1.206	1.321	1.097
Meat, edible meat offal, prepared, preserved	0.754	0.682	1.223	1.185	1.088
Milk and dairy products	1.005	0.424	1.300	1.006	1.224
Butter and other fats and oils derived from milk	1.177	1.102	1.312	1.077	1.206
Cheese and curd	1.236	1.299	1.290	1.194	1.255
Eggs, eggs' yolk, albumin	1.048	1.063	1.096	1.087	1.404
Fish, fresh, chilled or frozen	0.829	0.942	1.137	1.226	1.552
Fish, dried, salted, smoked	0.886	1.057	1.229	1.251	1.499
Crustaceans, mollusks, and aquatic invertebrates	1.057	1.222	1.332	1.302	1.500
Fish and aquatic invertebrates	1.109	1.219	1.304	1.343	1.543
Wheat and meslin	0.657	0.940	1.041	0.804	1.012
Rice	1.005	1.109	1.222	1.067	1.110
Barley	0.995	1.085	1.094	1.045	1.016
Maize	1.093	1.226	1.267	1.078	1.055
Cereals, unmilled	1.146	1.054	1.120	1.004	1.014
Flour (wheat and meslin)	0.838	0.938	1.038	0.911	1.020
Other cereal meals and flour	0.807	0.990	1.114	0.932	1.099
Cereal preparations, flour of fruits or vegetables	1.063	1.033	0.883	0.995	0.741
Vegetables	1.112	0.901	0.904	1.154	1.114
Vegetables, roots, tubers, prepared, preserved	1.004	1.106	1.055	1.076	1.127
Fruits and nuts	1.055	0.811	0.268	0.260	0.228
Fruit, preserved	1.197	0.736	1.096	0.776	1.194
Fruit and vegetable juices	1.208	0.683	1.182	0.812	0.997
Sugar, molasses and honey	1.083	0.469	1.228	1.111	0.809
Sugar confectionery	1.115	1.195	1.209	1.137	1.102
Coffee and coffee substitutes	1.306	1.203	1.314	1.290	1.541
Cocoa	1.227	1.224	1.557	1.295	1.526
Chocolate	0.994	1.250	1.506	1.302	1.553
Tea and mate	1.290	1.117	0.905	1.032	0.705
Spices	1.166	1.008	0.880	1.117	0.901
Feeding stuff for animals	0.884	0.900	1.344	1.046	1.117
Margarine	1.306	1.199	1.402	1.261	1.492
Edible products and preparations	0.773	1.023	1.189	1.177	1.203
Oilseeds and oleaginous fruits	0.449	1.112	1.254	0.856	1.188

Note: Green cells—product groups for which all four RCA, RTA, LI, and DRC match; yellow cells—product groups with advantage on domestic resource costs. Source: Authors' calculation based on [26,104–108].

3.5. Competitiveness Distribution

Proceeding from the above results, competitive positions primarily include horticultural products such as apricots and plums (the two most competitive products in Kyrgyzstan, Uzbekistan, Tajikistan, and Turkmenistan), cherries (Kyrgyzstan, Uzbekistan, and Turkmenistan), and grapes (Uzbekistan and Tajikistan) as well as wheat and meslin (Kazakhstan), milk and dairy products (Kyrgyzstan), flour (Kazakhstan), honey (Kyrgyzstan), and walnuts (Kyrgyzstan and Uzbekistan).

There are the products considered conditionally competitive as they obtain any of comparative, trade, or competitive advantage and DRC below market price. Kazakhstan and Kyrgyzstan may potentially promote their meat products (due to the developed livestock sector and cattle farming), fish (fishing and aquaculture production in the Caspian Sea and the lakes of Balkhash, Issyk-Kul, Zaysan, and Alakol), and feeding stuff for animals (abundant pastures). The countries of Central Asia are also conditionally competitive in the production of various cereals and their preparations, tea, and spices (Table 7).

Table 7. Allocation of agricultural products to competitiveness groups per countries.

Products	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Live animals	NC	MC	NC	NC	NC
Meat of bovine animals, fresh, chilled or frozen	CC	CC	NC	NC	NC
Other meat and edible meat offal	CC	CC	NC	NC	NC
Meat, edible meat offal, salted, dried	CC	CC	NC	NC	NC
Meat, edible meat offal, prepared, preserved	CC	CC	NC	NC	NC
Milk and dairy products	NC	C	NC	NC	NC
Butter and other fats and oils derived from milk	NC	MC	NC	NC	NC
Cheese and curd	NC	MC	NC	NC	NC
Eggs, eggs' yolk, albumin	NC	NC	NC	NC	NC
Fish, fresh, chilled or frozen	CC	CC	NC	NC	NC
Fish, dried, salted, smoked	CC	MC	NC	NC	NC
Crustaceans, mollusks, and aquatic invertebrates	MC	NC	NC	NC	NC
Fish and aquatic invertebrates	MC	NC	NC	NC	NC
Wheat and meslin	C	CC	NC	CC	NC
Rice	NC	NC	MC	NC	NC
Barley	CC	NC	NC	MC	NC
Maize	NC	NC	NC	NC	NC
Cereals, unmilled	MC	MC	NC	MC	NC
Flour (wheat and meslin)	C	CC	MC	CC	MC
Other cereal meals and flour	CC	CC	MC	CC	NC
Cereal preparations, flour of fruits or vegetables	MC	MC	CC	CC	CC
Vegetables	MC	CC	CC	MC	MC
Vegetables, roots, tubers, prepared, preserved	MC	MC	MC	MC	MC
Fruits and nuts	MC	C	C	C	C
Fruit, preserved	MC	CC	MC	CC	MC
Fruit and vegetable juices	MC	CC	MC	CC	CC
Sugar, molasses and honey	NC	C	NC	NC	CC
Sugar confectionery	NC	MC	NC	NC	NC
Coffee and coffee substitutes	NC	NC	NC	NC	NC
Cocoa	NC	NC	NC	NC	NC
Chocolate	CC	NC	NC	NC	NC
Tea and mate	NC	MC	CC	NC	CC
Spices	NC	NC	CC	MC	CC
Feeding stuff for animals	CC	CC	NC	MC	NC
Margarine	MC	MC	NC	NC	NC
Edible products and preparations	CC	MC	NC	MC	NC
Oilseeds and oleaginous fruits	C	MC	NC	CC	MC

Note: Green cells—competitive (C); yellow cells—conditionally competitive (CC); orange cells—marginally competitive (MC); red cells—non-competitive (NC). Source: Authors' development.

The majority of agricultural products in Central Asia, however, are recognized as either non-competitive (no advantage on any of the four indexes) or marginally competitive (there are advantages, but DRC to produce a unit of a product is higher than the product is worth).

4. Discussion: Matching Central Asia's and China's Perspectives

4.1. Matching 1: Export Competitiveness of Central Asian Countries and China's Food Imports

The study demonstrates that the development of agricultural value chains in the countries of Central Asia is based on a narrow nomenclature of the most competitive products: Fruit, wheat, cereals, and meat. This corresponds with the earlier findings of Rillo and Nugroho [43], Adriano [109], and International Center for Agricultural Research in the Dry Areas [110] who all concluded that value chains in each of the Central Asian countries served their respective competitive sectors and were not deeply integrated with each other due to different competitive advantages.

Both comparative and competitive advantage theories suggest that a country specializes in production and trade in those products in which it possesses an advantage over its competitors. It is natural for a dry and hot region of Central Asia to lose out in the production of cocoa, coffee, and some crops (rice, maize, and barley) as well as for landlocked Tajikistan and Uzbekistan to be non-competitive in fishing. However, even in the conventional sectors of animal husbandry, fruit and vegetable processing, or edible products preparation, most of the Central Asian economies lose their competitive advantages as corresponds with the World Bank's [77] findings of the erosion of competitive advantages in the region due to the outdated facilities, lack of investment and technologies, underdeveloped infrastructure, low productivity, poor veterinary and phytosanitary systems, and low capacity to comply with packaging, marketing, and other requirements of the contemporary global market.

Apart from a pure trade advantage on one side, an establishment of a sustainable value chain involves the creation of stable demand for a product on the other [111,112]. Demand is one of the four interrelated components of success in international trade in Porter's theory of competitive advantage [113], as well as an integrated element in various value chain concepts, such as global commodity chain [114,115], world economic triangle [116], global value chain [117], Porter's value chain [113], commodity chain [118], and "filiere" approach [119].

On the one side of the chain, there are Central Asian suppliers of fruits, cereals, meat and dairy, and some other products identified as either competitive or conditionally competitive. What is the demand on the other side? China is a country where agricultural sector is intended to feed over 1.3 billion people [120]. This fact alone brings a substantial portion of risk to the stability of agricultural value chains globally. Since the late 1970s, China has been gradually opening its market to food import and external actors [121], as well as encouraging the penetration of its state-backed agricultural companies to value chains abroad. The most recent food security strategy approved in 2019 outlined international collaboration in agriculture as one of the tools to sustain food security of China and thus contribute to the improvement of food security globally [25].

By now, China has achieved self-sufficiency on staple agricultural products on the level above 90% [122]. For some products, nevertheless, the country still depends on imports being the world's top importer of soybeans, cotton, palm oil, and sugar. Oilseeds and oleaginous fruits, in which Kazakhstan and Turkmenistan possess competitive advantages, account for one-fifth of China's total agricultural imports in 2000–2018 (Table 8). Oilseeds and vegetable oils and fats will remain the predominant imported agricultural commodities of China for at least a couple of decades [120]. Currently, self-sufficiency in oilseeds is the lowest among agricultural products in China and is expected to decrease in 2020–2040 [120]. The match between demand and advantage makes soybeans the most perspective crop to produce and export to China. Fruits and nuts, in which all the countries of Central Asia, except Kazakhstan, enjoy the highest advantages, are also perspective for export, but China has been improving its self-sufficiency in fruits since mid-2000s. The demand is still high for exotic tropical fruits not grown in Central Asia. Moreover, there are advantages-demand overlaps for milk and dairy products (Kyrgyzstan), feeding stuff for animals (Kazakhstan and Kyrgyzstan), and sugar and honey (Kyrgyzstan).

Table 8. China's top import products and Central Asia's competitive advantages.

Products	Share in Imports *, Percentage	Imports/GDP Ratio **, Percentage	Competitive Advantage
Oilseeds and oleaginous fruits	20.776	76.183	Kazakhstan, Turkmenistan
Fish, fresh, chilled or frozen	6.450	12.574	Kazakhstan, Kyrgyzstan
Feeding stuff for animals	6.086	20.419	Kazakhstan, Kyrgyzstan
Other meat and edible meat offal	4.807	16.055	Kazakhstan, Kyrgyzstan
Fruits and nuts	4.488	10.038	Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan
Edible products and preparations	3.425	13.800	Kazakhstan
Crustaceans, mollusks, and aquatic invertebrates	2.646	7.229	-

Table 8. *Cont.*

Products	Share in Imports *, Percentage	Imports/GDP Ratio **, Percentage	Competitive Advantage
Milk and dairy products	2.571	82.982	Kyrgyzstan
Barley	2.311	6.504	Kazakhstan
Vegetables	2.172	9.336	Kyrgyzstan, Tajikistan
Sugar, molasses and honey	1.683	69.027	Kyrgyzstan
Wheat and meslin	1.489	5.038	Kazakhstan, Kyrgyzstan, Turkmenistan
Rice	1.226	4.930	-
Cereals, unmilled	0.906	6.117	-
Meat of bovine animals, fresh, chilled or frozen	0.981	22.170	Kazakhstan, Kyrgyzstan
Cereal preparations, flour of fruits or vegetables	0.522	7.005	Tajikistan, Turkmenistan, Uzbekistan
Live animals	0.503	18.683	-
Fruit, preserved	0.414	14.864	Kyrgyzstan, Turkmenistan
Margarine	0.414	17.449	-
Chocolate	0.347	38.114	Kazakhstan
Vegetables, roots, tubers, prepared, preserved	0.291	7.385	-
Fish and aquatic invertebrates	0.284	6.910	-
Fruit and vegetable juices	0.244	18.793	Kyrgyzstan, Turkmenistan, Uzbekistan
Cheese and curd	0.221	44.170	-
Butter and other fats and oils derived from milk	0.217	37.372	-
Sugar confectionery	0.188	21.006	-
Fish, dried, salted, smoked	0.138	11.144	Kazakhstan
Tea and mate	0.083	2.378	Tajikistan, Uzbekistan
Spices	0.066	9.993	Tajikistan, Uzbekistan
Flour (wheat and meslin)	0.054	5.709	Kazakhstan, Kyrgyzstan, Turkmenistan
Other cereal meals and flour	0.032	8.225	Kazakhstan, Kyrgyzstan, Turkmenistan
Meat, edible meat offal, prepared, preserved	0.026	13.082	Kazakhstan, Kyrgyzstan
Meat, edible meat offal, salted, dried	0.003	10.663	Kazakhstan, Kyrgyzstan

Note: * share of a product *i* in total agricultural imports of China, average in 2000–2018; ** ratio of import volume of a product *i* to gross domestic output of a product *i*, average in 2000–2018. Source: Authors' calculation based on [26,123].

There is no match between Central Asia's competitive advantage in wheat and China's demand for grain. Currently, China supplies 95% of its own needs for grain [25], but in the coming decades, the demand for and import of grain crops is expected to rise rapidly [120]. Economic development, progressing urbanization and transformation of food consumption patterns along with the degradation of limited arable land and heavy use of fertilizers in China are likely to bring increased demand for all major crops in 2020–2040 [77,122,124]. Zhou [125], Zhou et al. [126], and the World Bank [77] attribute the growth in the consumption of food products of higher quality, nutrient value, and price in China (meat and meat products, milk and dairy products, and seafood) to the prejudice of cheaper and fewer nutrient crops. Consequently, Chinese meat and dairy producers demand more crops as fodder for agricultural animals which is a niche to be potentially occupied by the producers of feeding stuff for animals from Kazakhstan and Kyrgyzstan.

4.2. Matching 2: Production Advantages of Central Asian Countries and China's Agricultural Investments in the Region

How China can meet the challenge of growing demand for food and ensure the stability of food supply chains? As stated in the National Strategy on Food Security [25], among the solutions are the sharing of resources, support of the enterprises in going global, and encouragement of investment in agricultural products abroad. Foreign direct investment became an increasingly important element in sustainable development of agricultural value chains worldwide [127]. Being the most populous country in the world, China has been increasingly concerned in securing sustainable and sufficient food supply for its people. As the economic growth in China brings more purchasing power to the customers, the country has been emerging as a leading importer of food of all kinds, including high-quality and nutritious products, as well as a major player in outward agricultural investment [128]. According to Zhang and Cheng [129] and Cui and Shoemaker [130], the main task for China's overseas agricultural investment is to establish global value chains that would improve the stability of food supply. The country has been diversifying where it obtains crops that Chinese farmers are not able to grow in sufficient quantities domestically [122].

Many authors, including Bondaz et al. [131], Zhang [132], Shah [133], He et al. [134], and Huang et al. [135] share the vision of the BRI as a driver of China's new approach to its food security strategy and establishment of sustainable agricultural value chains across Eurasia. While the BRI's major focus in Central Asia is on the improvement of connectivity and facilitation of trade, it also involves investment in agriculture. Among the countries of Central Asia, Kazakhstan is most attracting country of foreign direct investment (70% of total investments in the region) [136] and the main recipient of agricultural investments from China (over $1 billion in 17 projects as of 2018) in processing and sale of rapeseed and sunflower seeds, oil crops, and fresh-frozen fish and fish products, construction of slaughterhouses and poultry farms, and establishment of a cluster in sheep farming and enterprises for deep processing of grain, flax, soybeans, and semi-finished meat products [137] (Table 9). In Uzbekistan, Tian Jean Nana and Exim Bank of China invested about $29 million to the establishment of a logistics hub in the Bukhara region for the processing of fruit and vegetables and meat and dairy products and exporting them to China. In Kyrgyzstan, Chinese companies invest to crop production, processing of agricultural products, and food industry [138].

Table 9. Major Chinese investment projects in agriculture * and Central Asia's competitive advantages.

<table>
<tr><th>Countries</th><th>Sectors with Chinese Investment</th><th>Sectors, in Which an Advantage Is Possessed</th></tr>
<tr><td rowspan="11">Kazakhstan</td><td colspan="2">Meat and meat products</td></tr>
<tr><td colspan="2">Fish and fish products</td></tr>
<tr><td colspan="2">Wheat and meslin</td></tr>
<tr><td></td><td>Barley and other cereals</td></tr>
<tr><td colspan="2">Processing of cereals</td></tr>
<tr><td colspan="2">Vegetables prepared, preserved</td></tr>
<tr><td colspan="2">Sugar, molasses, and honey</td></tr>
<tr><td></td><td>Chocolate</td></tr>
<tr><td></td><td>Feeding stuff for animals</td></tr>
<tr><td colspan="2">Edible products and preparations</td></tr>
<tr><td colspan="2">Oilseeds and oleaginous fruits</td></tr>
<tr><td rowspan="10">Kyrgyzstan</td><td colspan="2">Meat and meat products</td></tr>
<tr><td></td><td>Milk and dairy products</td></tr>
<tr><td></td><td>Fresh fish</td></tr>
<tr><td colspan="2">Wheat and meslin</td></tr>
<tr><td colspan="2">Processing of cereals</td></tr>
<tr><td colspan="2">Vegetables</td></tr>
<tr><td colspan="2">Fruit and nuts</td></tr>
<tr><td></td><td>Sugar and honey</td></tr>
<tr><td></td><td>Feeding stuff for animals</td></tr>
<tr><td colspan="2">Edible products and preparations</td></tr>
<tr><td rowspan="7">Tajikistan</td><td colspan="2">Wheat and meslin</td></tr>
<tr><td colspan="2">Maize</td></tr>
<tr><td></td><td>Cereal preparations</td></tr>
<tr><td></td><td>Vegetables</td></tr>
<tr><td colspan="2">Fruit and nuts</td></tr>
<tr><td></td><td>Tea and mate</td></tr>
<tr><td></td><td>Spices</td></tr>
<tr><td rowspan="5">Turkmenistan</td><td colspan="2">Wheat and meslin</td></tr>
<tr><td></td><td>Processing of cereals</td></tr>
<tr><td colspan="2">Fruits and nuts</td></tr>
<tr><td></td><td>Processing of fruit and vegetables</td></tr>
<tr><td></td><td>Oilseeds and oleaginous fruits</td></tr>
</table>

Table 9. *Cont.*

Countries	Sectors with Chinese Investment	Sectors, in Which an Advantage Is Possessed
Uzbekistan	Meat and meat products (red)	Meat and meat products (red)
	Milk and dairy products (red)	Milk and dairy products (red)
	Cereal preparations (yellow)	Cereal preparations (yellow)
	Fruit and nuts (green)	Fruit and nuts (green)
	Fruit and vegetable juices (yellow)	Fruit and vegetable juices (yellow)
		Sugar and honey (yellow)
		Tea and mate (yellow)
		Spices (yellow)

Note: * this study does not consider the cotton sector, one of the major attractors of Chinese investment in the region, as that not directly related to food production; green cells—C group; yellow cells—CC group; orange cells—MC group; red cells—NC group. Source: Authors' development based on [104–108,123].

In general, the directions of Chinese agricultural investment in the region intersect with competitive advantages of respective counties. In particular, there is a distinct match between the investment and advantages in horticulture. This finding, however, contradicts with Hofman [139], who argued that the investments in the production of unpreserved fruits in Central Asia were disadvantageous for Chinese agro holdings due to the impoverished storage and transport infrastructure and costly shipment to China. Indeed, there are substantial challenges to both the stability and economic efficiency of value chains due to the backwardness of infrastructure, geography, and landlockedness and remoteness of the region, but Chinese investors still enter joint projects in the production of fresh fruits and vegetables and other perishable products. Perspective sectors for Chinese companies to move to are dairy and sugar production in Kyrgyzstan, both in C group. In most of the sectors, where China currently invests to, Central Asian agricultural producers possess conditionally competitive advantages, according to our classification. Moreover, there are investment projects in the sectors where the advantages are either marginal or absent.

4.3. Matching 3: Sustainability of Agricultural Value Chains and Policy Implications of Competitiveness and Trade Potential Assessment

Despite the growing volume of joint agricultural projects, China's investment in the region primarily focuses on mining and construction with limited involvement in agricultural value chains [140]. Kurmanalieva and Parpiev [2] think that it would be difficult for Central Asian economies to diversify their value chains away from primary commodities towards processed goods, including agricultural. Nevertheless, the authorities in all countries of the region expect China to invest more in food production. The use of agricultural land by foreigners, however, remains a controversial topic across social groups in Central Asia. People are becoming concerned that China's growing investment in agricultural sector could result in land grabbing by Chinese companies and the influx of Chinese workers. For instance, in Kazakhstan, the protests forced the government to postpone the extension of the farmland lease period for foreigners from 10 to 25 years until December 2021. Along with economic, infrastructural, environmental, and climate challenges that confront food sector in Central Asia, emerging social issues pose new threats to the sustainability of agricultural value chains in the region and call for adequate policy responses.

Many of earlier studies, including Adriano [109], Pirmatov et al. [38], Akter et al. [30], Foggin [141], and Akramov [31], among others, found that policy efforts aimed at the fostering, coordination, and integration of agricultural value chains in Central Asia would lead to the improved performance of agricultural sectors and more stable food supply. Following on from the results of this study, we propose policy measures to be differentiated in such a way as to support and promote the advantages in C and CC groups and establish and protect those in MC and NC groups (Table 10).

Table 10. Policy measures to improve the sustainability of China–Central Asia agricultural value chains.

Competitiveness Groups	Policy Measures
C group	Diminishing of administrative barriers to export Development of production and logistics infrastructure, including as a part of the BRI Economic corridor approach to the development of value chains
CC group	PR and promotion of domestic products on Chinese market Support of "niche" export-oriented productions Subsidized loans for the development of export production Subsidized insurance of export-oriented productions
MC group	Income support of agricultural and food producers Reduction of production costs Programs for sustainable development and diversification of the rural economy Measures to prevent and offset the impact of sharp increases in agricultural imports Encouragement of Chinese investment in agricultural research and infrastructure, particularly, irrigation, storage, processing, and supply facilities
NC group	Direct payments to the producers of staple crops Comprehensive subsidies for agricultural inputs Subsidies for farm machinery purchases Subsidies for improved crop varieties Minimum grain purchasing prices Temporary storage options

Source: Authors' development.

For C group products, the competitive environment can be improved by reducing administrative barriers to export and implementing customs and tariff regulations of export. Currently, trade policy regimes in Central Asia vary from fairly liberal in Kyrgyzstan and Kazakhstan to quite restrictive in Uzbekistan and Turkmenistan [142]. According to Raballand and Andresy [143] and Jha [144], the variability of export regimes across the countries in Central Asia very much depends on the membership in the WTO. Kyrgyzstan (the most liberal trade regime among the five economies, WTO member since 1998), Kazakhstan, and Tajikistan have made extensive efforts to improve export regulations and facilitate the development of core automation of trade procedures. Uzbekistan and Turkmenistan (both are still out of the WTO framework of trade regulations), on the contrary, lack transparency and stability in their trade policies. Mogilevskii and Akramov [13] found that Uzbekistan and to a lesser degree other countries in the region extensively introduced export duties and even export bans to reduce or prevent the exports of raw agricultural products which might be processed domestically. These include oilseeds, cereals, fodder crops, vegetable oil, live animals, meat, and sugar. Our study, however, demonstrates lower competitiveness of food processing industries across Central Asia compared to crop production which means such export restrictions favor "managed" trade but distort real competitive advantages and bring instability to value chains.

For a value chain to gain sustainability, it is imperative to develop production, logistics, and supply infrastructure. The potential solutions include the reduction of export transaction costs and the improvement of the access of Central Asian producers to the Chinese market. All countries of the region currently rank low in the Trading Across Borders Indicator of the World Bank's Doing Business Index (Kyrgyzstan ranks the highest among the five, 89th out of 189 economies in 2019) [145] due to the high number of documents and procedures required to conduct an export delivery. Even for high-competitive C group products, these barriers reduce competitiveness and call for a pro-active removal of export constraints for efficient trade facilitation. This agrees with White [146], who demonstrates that lowering the number of documents required to export would yield shorter export times, decrease the opportunity for corruption and other uncertainties along the value chains, and increase the advantage of Central Asian products in the global market.

As this study demonstrates, some of the competitive sectors lack Chinese investments, while in some cases, Chinese companies invest to the sectors where the advantages are marginal or negligible. The BRI as an umbrella initiative aimed at the development of connectivity on the macro level may allow agribusiness to concentrate around major infrastructure investment, potentially, in a form of the economic corridor, a complex of production, logistics, and trade arrangements. A concept of the economic corridor approach to the development of agricultural value chains in Central Asia is advocated by Rillo and Nugroho [43] and Nogales [147]. Due to the landlockedness and low intraregional and international transport connectivity, economic corridors have been central to the agenda in most of the Central Asian countries. Specifically, Central Asian Regional Economic Cooperation (CAREC) program has laid the groundwork for economic corridor development in Central Asia by mobilizing over $34.5 billion investments in the establishment of multimodal transportation networks [148]. Concerning economic corridor approach, CAREC supports simplification and harmonization of customs procedures, information and communication technology development and data exchange, risk management and post-entry audit, joint customs control, and regional transit development [148]. In relation to C group value chains, the economic corridor approach may allow to attract more investment in the most competitive sectors and stimulate economic activities along the territories in which the corridor is established.

For CC group products, it would be rational to affect the demand side of the value chains. The efforts should be focused on the promotion of CC products outside and creating demand on the Chinese market. Among CC products, the most demanded in China are oilseeds, wheat, and other cereals. In Central Asia, the major hindrances to the stability of value chains in crop production are large distances and high storage and transportation costs due to the scarcity, fragmentation, and deterioration of infrastructure. Kazakhstan is developing its railway and road infrastructures, including in the framework of Nurly Zhol initiative, a national plan to develop and modernize roads, railways, ports, and IT infrastructure, in an attempt to establish a network of multimodal transport hubs and integrate them with China's BRI economic corridors [149]. In other countries of the region, capital stocks devoted to infrastructure development are lower, while the obsolesce of infrastructure appears to affect export-oriented agricultural value chains in a negative way [142]. This is especially relevant for C and CC group products, including such key export items as fruits and vegetables which are perishable and sensitive to delays in transportation [13].

Crop producers may benefit from the investment in grain market infrastructure, subsidized loans, and export insurance programs. These measures correlate with the recommendation of Svanidze et al. [150] to complement trade and infrastructure-enhancing policies with the support of domestic producers in order to bring more stability to value chains in crop production. The establishment of tax incentives along with the allocation of preferential credits for agribusiness are recommended by Pirmatov et al. [38] among the measures to support competitive advantages. Pomfret [42] also advocates technological improvements of grain production and supply infrastructure and financial support of farmers as the conditions of increasing efficiency in the grain sector. Technological improvements, for instance, are required to help to overcome technical barriers for trade established in China and other export markets. They include compliance with health, veterinary, and phytosanitary requirements. Due to the overall underdeveloped veterinary and phytosanitary systems and quality infrastructure in Central Asia, agricultural producers encounter difficulties to comply with safety regulations applied internationally.

For MC products, the aim of policy measures is to protect vulnerable and eroding competitive advantages. This task demands the application of indirect economic measures focused on the increase of competitiveness, for instance, income support or reduction of production costs in agriculture. Measures to prevent and offset the impact of the increases in agricultural imports should be introduced, including anti-dumping measures, countervailing and safeguard measures, and a mechanism to cope with agricultural subsidies. On China's side, there should be a support of agricultural production in Central Asia in the form of agricultural research. It agrees with earlier findings of Babu and Reidhead [37], who propose the investment in information generation and building capacity in farming technologies and knowledge as fundamental aspects of long-term sustainable development of value chains in Central Asia. Along the same line goes the argumentation of Danabayeva [151] who observes that a major challenge to sustainability and performance of the agricultural sector faced by Central Asian economies is the transformation of existing value chains into the knowledge-based ones.

As regards those value chains which involve non-competitive food and agricultural products, they should be focused on the domestic market in order to improve food security along the availability pillar and increase farmers' incomes through a system of agricultural support policies, including direct payments for the production of major crops, subsidies for agricultural inputs, subsidies for farm machinery purchases and improved crop varieties, minimum purchasing prices for crops and other staple foods, and temporary storage options. Such measures aimed at the support of both non-competitive and marginally competitive agricultural products will establish the conditions for the strengthening of competitive advantages in the long run, improve the performance of agricultural producers, drive them to expand their production facilities, and thus contribute to the improvement of food security and sustainability of agricultural value chains in the countries of Central Asia.

5. Conclusions

The five-stage approach allowed to (1) reveal comparative, trade, and competitive advantages of Central Asian economies in agricultural trade, (2) match those advantages with production capabilities of agricultural sectors, (3) divide products into groups according to the degree of competitiveness. It is revealed that the countries of Central Asia are able to compete internationally in labor-intensive horticultural products and some crops, primarily, wheat and oilseeds. Capital and technology-intensive sectors of animal husbandry, livestock production, and food processing are all low competitive across the region (to a certain degree, the exceptions being Kazakhstan and Kyrgyzstan where some meat and dairy products are recognized conditionally competitive).

The matching between the revealed advantages of Central Asian agricultural sectors and China's current imports, investment in the region, and future demand in food demonstrates several opportunities that can be embraced from closer China—Central Asia collaboration. First, there is a growing demand for diverse food products in China. Currently, Central Asia is indeed a very modest contributor to China's agricultural imports. None of the five countries of the region is now capable to pose any substantial influence on food supply in China. However, at least in C and CC product groups (oil seeds, fruit, wheat, cereals, feeding stuff for animals), Central Asia can become one the sources of food import in the diversified food supply network. Second, closer agricultural ties between China and the countries of Central Asia in the framework of the BRI, economic development corridor, as well as agricultural investment, knowledge-sharing, and technology will ensure regional food supply and enhance the sustainability of agricultural value chains. Third, the development of agricultural value chains between Central Asia and China may have food security and pro-poor benefits as it would involve farmers in the international food supply and provide more jobs and income opportunities to low-income people in rural areas.

To enhance the integration between Central Asia's supply and China's demand sides of the value chains, the authors construct a set of policy responses to major advantage-related challenges. The approach is that the stakeholders in C and CC value chains should be supported to implement or develop competitive advantage and expand exports, while MC and NC value chains should be aimed at the domestic markets to contribute to the solution of the food insecurity problem. It is expected that the implementation of policy measures will facilitate the concentration of the resources toward competitive and potentially competitive products, protect and promote vulnerable competitive advantages in the value-added sectors of animal production and food processing, enhance the competitiveness and productivity of the stakeholders within the chains, thus contributing to better performance of agricultural sectors in Central Asia, agriculture-driven economic growth in rural areas, and more sustainable food supply in the macro-region of Eurasia at the end.

This study is a preliminary attempt to roughly link trade and competitive advantages and production capabilities with the sustainability of value chains in agriculture. Thorough work is required to eliminate the existing limitations and make the approach relevant in a wider sustainability-related context. Due to the fact that this study considers China as a single trade partner, there is a rationale to extend the research to a wider pool of trade partners of Central Asian economies, for instance, Russia, the Middle East, and the EU. This will allow to assess the degree of diversification in value chains and suggest the responses to possible demand and price fluctuations on particular markets. Intra-regional agricultural trade in Central Asia has been stagnating since the 1990s due to the fact that no country possesses a decisive advantage over the others. In almost similar climate, geographical, technological, and economic conditions of agricultural production, they all produce similar products of a rather narrow assortment. There is no economic basis for intensive exchange then. Still, it is worth studying those marginal competitive advantages which exist outside the traditional sectors of horticulture and crop production in order to understand how they may be promoted for the benefit of intra-regional supply chains. Quality constraints to expanding agricultural exports from Central Asia should be studied primarily in relation to C and CC product groups. Moreover, there is a rationale in analyzing the effects of trade policy constraints (both export restrictions from Central Asia's side and import policies of trade partners) for the stability of value chains.

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Exploring Foreign Direct Investment–Economic Growth Nexus—Empirical Evidence from Central and Eastern European Countries

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Abstract: This study aims to examine the link between foreign direct investment (FDI) inflows and economic growth, also considering several institutional quality variables, as well as sustainable development goals (SDGs) set in the 2030 Agenda for Sustainable Development. By estimating panel data regression models for a sample of 11 Central and Eastern European countries, from 2003 to 2016, the empirical outcomes provide support for a non-linear relationship between FDI and gross domestic product per capita. Regarding institutional quality, it is found that control of corruption, government effectiveness, regulatory quality, rule of law, and voice and accountability positively influence growth, while political stability and absence of violence/terrorism is not statistically significant. Moreover, SDGs such as poverty, income distribution, education, innovation, transport infrastructure, and information technology are noteworthy drivers of growth. The outcomes of panel fully modified and dynamic ordinary least squares partly confirm the findings. The panel vector error-correction model Granger causalities provide support for a short-run one-way causal association running from FDI to growth and a long-run two-way causal connection among FDI and growth. Furthermore, in the long run, unidirectional causal relationships running from each institutional quality indicator to economic growth and FDI are set out.

Keywords: foreign direct investment; economic growth; panel data regressions; panel co-integration; Fully Modified Ordinary Least Square (FMOLS) and Dynamic Ordinary Least Square (DOLS); panel vector error-correction model; Granger-causality

1. Introduction

In an increasingly globalized worldwide economy, investment is viewed as a catalyst for economic growth. For instance, foreign direct investment (FDI) influx supports development via productivity intensification through new investment, improved technologies, and decision-making abilities to the host nations [1–6]. Therefore, FDI lifts the host nation's economy by rising investible capital and by technological spillovers [7,8]. FDI is regarded as a collection of physical and immaterial capital that is shifted across borders and spill over to the local economy producing growth [9]. Similarly, FDI is a crucial factor in global economic integration and generates direct, stable, and long-lasting relationships between economies [10]. Moreover, Farla, et al. [11] marked off the "crowding in" which pretend that FDI will bring more investment from private inland sources and the "crowding out" which is the reverse.

In neoclassical models, long-term growth may ensue as the outcome of exogenously driven technical evolution and/or labor force growth [6]. Accordingly, new domestic businesses or the extension of the existing ones involve employment of individuals, therefore laying the grounds for the decline of the unemployment rate. Vojtovic, et al. [12] argued that FDI is generally the key provider of capital to founder of jobs for local workers, thus being connected to growth. Likewise, the link between FDI net influxes and poverty lessening is strongly significant [13]. Nevertheless, institutions exert a significant role in technological development [14]. Hence, host-country corruption impacts multinational firms' foreign investment decisions by producing economic settings that are either fortunate for or hostile to coherent economic activity [15]. Corrupt governments may hinder human progress that rise from FDI, while large levels of bribery will harmfully influence the positive outcome that FDI may have on human development [16]. Chen, et al. [17] proved that foreign companies from countries with higher institutional quality exhibit more efficient investment activities than firms from countries with poor institutions. Gossel [18],Barassi and Zhou [19],Egger and Winner [20] argued that corruption may act as a "grabbing hand" since paying bribes generates a variety of financial misrepresentations, but also as a "helping hand" due its facility to accelerate the bureaucratic courses. Khamfula [21] found that when the level of corruption rises, then FDI is prejudiced, but when the level of corruption is related with local investment, the effect on FDI is beneficial. Hence, Gilmore, et al. [22] emphasized a set of factors which drive the selection of host market: "FDI as a preference to other forms of foreign market entry, size, and growth of the host market, government emphasis on FDI and financial incentives, economic policy, cultural closeness, costs of transport, materials and labor, resources, technology, political stability, infrastructure".

With the enlarged incorporation of capital markets after the 1990s, FDI streams turn out to be more prevalent amid the developing nations [23]. FDI supported Central and Eastern European countries (hereinafter "CEECs") to change their product structure to get comparable to the more developed European Union (hereinafter "EU") nations. Therefore, momentum to economic growth is expected, alongside mitigation of the development gap among the more advanced CEECs and the EU [24]. For instance, Damijan and Rojec [25] established that FDI is a central driver of manufacturing field reform and productivity growth in Central European Countries. Different to other capital streams, FDI is less unstable and does not show a pro-cyclical conduct [26]. Likewise, FDI has an crucial role in the enhancement and structural recovery of the CEECs [27]. However, emerging states with matching economic and state governance structures fail to entice a comparable level of inward FDI due to unproductive business setting [28]. These states should counterbalance the compromise from the advantages that ensue from FDI, such as technology transfer and employment, with the costs allied with increased short-term flows [29]. Fawaz, et al. [30] highlighted extensive variances across high-income and low-income developing nations with reference to institutions, openness in capital markets, aversion to redistribution policies, or culture. Thus, Lipsey [31] argued that nations which show reliable and predictable legal systems and efficient public administration may get more investment than states with deprived governance. In the same vein, Tun, et al. [32] strengthened that better institutions entice more FDI inflows since it creates for multinational corporations a propitious business and investment environment. Nonetheless, according to Henderson [33], favoritism entails boundaries in capital markets, export/import markets, and licensing of production rights, all supporting companies that locate in the national capital. Also, Kottaridi, et al. [34] claimed that foreign investors are not confident in Central and Eastern Europe (CEE) countries' governments concerning proper use of funds in education. Hence, transition economies show lack of transparency, weak standards of business conduct, poor protection of creditor and minority shareholder rights [35]. The Central and Eastern European countries register fragile economic and social institutions, but show a high potential of economic growth attributable to unsaturated markets, as well as a great extent of FDI appeal because of the geopolitical status of the region [5]. Nevertheless, CEECs show a poor knowledge regarding harnessing the capital richness at their disposal, thus requiring an extended time for getting rid of bureaucratic impediments [36].

Previous papers explored the effect of FDI and institutional quality on economic growth for datasets covering Association of Southeast Asian Nations (hereinafter "ASEAN") states [37], developing countries, located in the lower- and middle-income groups [38], developing markets and developed economies [39], non-OECD nations [40], Pacific Island countries [41], African nations [42], North African states [43], Southern African countries [44], sub-Saharan African nations [45] or various groups of nations [46]. Therefore, the empirical evidence on foreign direct investment, institutional quality, economic growth link is limited for the CEECs. Throughout the communist regime, the transition economies were isolated, falling behind the Western part with reference to key technologies, skills, and capabilities [47]. The analysis of FDI within this region is important since it has acted as an imperative instrument for catching up. As such, the primary aim of current research is to empirically explore the influence of FDI on economic growth, also considering the institutional quality, for the case of CEECs. As well, measures regarding the 2030 Agenda for Sustainable Development [48] are covered, namely poverty (Goal 1: End poverty in all its forms everywhere), income distribution (Goal 10: Reduce inequality within and among countries), education (Goal 4: Quality education), innovation, transport infrastructure and, information technology (Goal 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation), along with country-level controls. Subsequently, the causal associations between economic growth, FDI, and institutional quality will be explored. Our study differs from prior surveys on CEECs [5,12,49] in two ways: first, we consider the institutional context and, secondly, we provide evidence on the existing causal relationships. The novelty of current research is the broader inclusion of all Worldwide Governance Indicators, especially for the CEECs, as proxies for institutional quality, namely control of corruption, government effectiveness, political stability and absence of violence/terrorism, regulatory quality, rule of law estimate, voice, and accountability.

The remainder of the manuscript is organized as follows. The second section provides a survey of the related empirical studies. The third section presents the econometric methodology, specifically database, variables, and quantitative methods. The fourth section reports on the selected data and shows the quantitative findings of the study. The final section provides concluding remarks and policy recommendations.

2. Literature Survey

2.1. Earlier Papers Worldwide on FDI–Economic Growth Connection

The causal link between foreign direct investment (hereinafter "FDI") and gross domestic product (hereinafter "GDP") growth can run in either way [50]. In line with the "FDI-led growth hypothesis", FDI influxes can arouse growth for the host countries by rising the capital stock, generating new job opportunities, and easing the spread of technology. Conversely, the "market size hypothesis" supposes that a fast GDP growth making new investment opportunities in the host state can also cause higher inflows of FDI. Even if FDI is predictable to increase host economic growth, Zhang [51] exposed that the degree to which FDI is growth-enhancing appears to hinge on nation-specific features.

Iamsiraroj and Doucouliagos [52] performed a meta-regression analysis and emphasized a positive link between growth and FDI, being higher among single country investigations than within cross-country examinations. As such, Leitão and Rasekhi [53] explored the effect of FDI on real GDP per capita of Portugal, from 1995 to 2008, via panel data fixed-effects and random-effects regression models and found that foreign direct investment promotes growth. Mahapatra and Patra [54] supported the noteworthy role of FDI towards economic growth in India. Using provincial panel data from China, Chan, Hou, Li and Mountain [3] found both in the short and long-run that FDI has a significantly positive effect on GDP. The South Asian Association for Regional Cooperation (SAARC) was explored by Saini, et al. [55] which shown that FDI influx positively influence real GDP, gross national income, and export growth, but negatively financial position and trade openness. Likewise, Mahadika, et al. [56] provided evidence for Indonesia by means of vector autoregressive model that there is a long-term connection amid GDP, FDI, and export volume. Alshamsi, et al. [57] estimated an auto regressive distributed lag model for The United Arab Emirates and confirmed that GDP per capita had a significant positive connection with FDI. For the case of South Africa, Sunde [58] identified unidirectional causality running from foreign direct investment to economic growth. Kinuthia and Murshed [59] highlighted that economic growth drives growth of FDI in Kenya, whereas increase in FDI inflows Granger-causes an increase in economic growth in Malaysia. On the contrary, Akinlo [60] established for Nigeria that FDI positively influence growth, but after a sizable lag and it is not significant. In the same vein, Abdallah and Abdullahi [61] employed the vector error-correction model as method of estimation for Nigeria during 1980–2009 and revealed the lack of causal association among FDI and growth in the short term, but a negative relationship in the long term. Also, Yalta [50] noticed that there is no statistically significant association between FDI and economic growth in China. For the case of Turkey, from 1992–2007, Temiz and Gokmen [8] proved both in the short and long-run the lack of significant relationship between FDI and economic growth. Carbonell and Werner [62] reinforced for Spain that FDI is not a driver of growth.

Furthermore, Herzer, et al. [63] pointed out that cross-country studies mostly suggest a positive role for FDI in stimulating economic growth. Ndiaye and Xu [64] studied seven countries belonging to the West African Economy Monetary Union and confirmed the positive influence of FDI on growth. For a dataset comprising 35 developing and 31 developed nations, Ketteni and Kottaridi [9] noticed a positive impact of FDI on growth, but a growing effect as the share of FDI within the state increases. In contrast, Schneider [65] revealed for a panel sample of 47 developed and developing nations, from 1970 to 1990, that FDI show no significant relationship with economic growth, except for developed countries. As well, Herzer, Klasen and Nowak-Lehmann [63] noticed for 28 developing states that there occurs neither a long-term, nor a short-term effect of FDI on growth. Moreover, Dutta and Roy [66] proved that the association between financial development and FDI inflows is strictly non-linear, similar to Kottaridi and Stengos [67] which confirmed that a non-linear association occurs between FDI influxes and growth. By means of threshold regression, Jyun-Yi and Chih-Chiang [68] documented that FDI can endorse economic growth when the host nation has reached a particular threshold of development, initial GDP, and human capital. Correspondingly, Nguyen and To [37] found two threshold levels of FDI.

An overview of the studies on the foreign direct investment–economic growth nexus worldwide is provided in Table 1.

Table 1. Earlier studies on FDI and economic growth worldwide.

Author(s)	Time Span	Database	Empirical Methods	Outcomes
Awad and Ragab [42]	1989–2014	53 African nations	Linear dynamic panel data model	Positive effect of FDI on growth
Alvarado, et al. [69]	1980–2014	19 Latin American states	Panel data fixed-effects models	FDI does not have a positive influence on growth except high-income countries (Chile and Uruguay)
Malikane and Chitambara [44]	1980–2014	8 Southern African states	General Methods of Moments (GMM)	FDI has a direct positive influence on economic growth
Iamsiraroj [46]	1971–2010	124 cross-country data	Simultaneous system of equations	Bidirectional relationship between FDI and economic growth
Mahmoodi and Mahmoodi [70]	1986–2013	8 European developing nations and 8 Asian developing states	Panel-VECM	Two-way causality between GDP and FDI for the European developing panel
Gui-Diby [71]	1980–2009	50 African nations	SYS-GMM	Negative link among FDI inflows and economic growth from 1980–1994 Positive link between FDI influxes and economic growth from 1995–2009
Omri and kahouli [72]	1990–2010	13 Middle East and North Africa states	GMM	Two-way causal relationship between foreign investment and economic growth
Feeny, Iamsiraroj and McGillivray [41]	1971–2010	209 states	Ordinary Least Squares and GMM	FDI is related with higher rates of economic growth in the Pacific
Lee [73]	1971–2009	19 nations of the G20	Co-integration tests and fixed-effects models	FDI influxes drive economic growth
Freckleton, Wright and Craigwell [39]	1998–2008	42 developing nations and 28 developed states	Panel dynamic ordinary least squares	In both the short-run and the long-run, FDI has a significant impact on economic growth
Tekin [74]	1970–2009	18 least developed countries	Panel Granger-causality	FDI Granger-cause GDP in Benin and Togo GDP Granger-cause FDI in Burkina Faso, Gambia, Madagascar, and Malawi
Pegkas [1]	2002–2012	18 Eurozone nations	Fully Modified OLS (FMOLS) and Dynamic OLS (DOLS) methods	FDI positively influence economic growth
Mahembe and Odhiambo [7]	1980–2012	Southern African Development Community (SADC) nations	Granger-causality	One-way causal flow from GDP to FDI in the middle-income states Lack of causality in low-income nations
Vojtovic, Klimaviciene and Pilinkiene [12]	1997–2014	11 Central and Eastern Europe (CEE) countries	Granger-causality and Vector autoregression (VAR)	FDI Granger-causes GDP

Source: Authors' work based on existing literature.

2.2. Previous Studies in CEECS on FDI–Economic Growth Link

Transition economies may benefit from FDI since it could cover the current account scarcity, fiscal deficit, also supplementing insufficient inland funds to finance both ownership change and capital formation [35]. The CEECs reveal the advantage of refining their legal and institutional backgrounds as a prerequisite for joining the EU, thereby improving their benefits in order to call foreign investors [75]. In this regard, Jones, et al. [76] emphasized that EU affiliation had a significant consequence on the FDI in the CEECs, more than doubling the amount of the projects placed in these states compared to before the beginning of the accession dialogs. As such, a positive impact of FDI on growth is predictable. For instance, Campos and Kinoshita [77] explored 25 transition economies in Central Europe and in the former Soviet Union from 1990 to 1998 and found that the effect of FDI on economic growth is positive and statistically significant. Apergis, et al. [78] explored 27 economies in transition during 1991–2004 and concluded that FDI has a significant connection with economic growth in the case where all states are encompassed in the sample. Nevertheless, after the sample was divided into low- and high-income nations and in states with effective and not effective privatization plans, the inference preserve only for the case of the high-income economies and economies with fruitful denationalization agendas. Yormirzoev [79] investigated the states of Central and Eastern Europe, alongside the Commonwealth of Independent States, from 1992 to 2009 and confirmed a positive association between FDI and growth. Hlavacek and Bal-Domanska [49] investigated Central and Eastern European nations amid 2000 and 2012 and proved that statistically significant associations occur among economic growth, FDI, and investment growth. By exploring 16 Central, Eastern, and Southeastern European states during 1998–2013, Miteski and Stefanova [80] documented that FDI influxes in industry and services positively influence economic growth, whereas FDI in the construction sector did not show a statistically significant effect.

On the contrary, Mencinger [81] proved for a sample of eight EU candidates in 2004 a negative relationship between FDI and growth explained by the fact that takeovers were the prime means of entrance for overseas investors, while the capital employed for purchasing the companies was later focused on consumption and imports, thus failing to increase efficiency. Bačić, et al. [82] explored 11 CEECs from 1994 to 2002 and found that FDI is insignificant for growth. Kherfi and Soliman [83] found a negative or statistically insignificant effect of FDI on economic growth in MENA and non-EU accession CEECs, but a positive impact only in EU accession countries. Hence, FDI role concerning growth in transition economies is conditional upon applying extensive economic transformations or pointing out solid engagement to completing such reforms. As well, Ferencikova and Dudas [84] analyzed eight new EU member states during 1993–2003 and proved that the influx of FDI did not support economic growth, whereas wide FDI influxes are followed by slow GDP growth. Curwin and Mahutga [85] reinforced for 29 Central and Eastern European and Eurasian post-socialist transition nations from 1990 to 2010 that FDI diffusion lessens economic growth in the short and long term. Saglam [86] established for 14 European transition states for the period 1995–2014 that economic growth rate decreases by 0.0162% when FDI increases by 1%.

A summary of the existing literature on the foreign direct investment–economic growth nexus in CEECs is provided in Table 2.

Table 2. Earlier studies on FDI and economic growth in CEECs.

Author(s)	Time Span	Database	Empirical Methods	Outcomes
Vojtovic, Klimaviciene and Pilinkiene [12]	1997–2014	11 CEECs	Granger-causality and VAR	FDI Granger-causes GDP
Comes, et al. [87]	2010–2016	7 CEECs	The method of least squares and the method of least squares with dummy variables	Positive influence of FDI on economic growth
Simionescu [88]	2003–2016	8 CEECs	Bayesian bridge regressions	FDI was the most significant driver of economic growth
Belaşcu, Popovici and Horobeţ [75]	1999–2013	5 CEE countries	Panel least squares regression	FDI have a positive influence on economic growth
Bayar [89]	2003–2015	11 CEECs	Panel causality test	Greenfield and brownfield investments positively impact economic growth, but the effect of greenfield investments was higher
Silajdzic and Mehic [90]	2000–2011	10 Central and East European countries	OLS and Granger-causality test	FDI positively influence economic growth
Silajdzic and Mehic [91]	2000–2013	10 Central and East European countries	OLS with panel-corrected standard errors - PCSE (fixed-effect)	FDI contribute to economic growth
Albulescu [92]	2005–2012	13 CEECs	System-GMM	Direct and portfolio investments impact long-term economic growth
Pharjiani [93]	1995–2012	10 CEECs	Ordinary least squares, random effects, fixed effects, first differences estimation	Positive link between FDI and economic growth
Sârbu and Carp [94]	2000–2013	Romania	OLS and Johansen co-integration	FDI positively influence economic growth
Nistor [95]	1990–2012	Romania	OLS	FDI inflows positively influence GDP
Mehic, et al. [96]	1998–2007	Seven southeast European nations	Prais–Winsten regression with panel-corrected standard errors	Positive and statistically significant impact of FDI on economic growth
Acaravci and Ozturk [26]	1994–2008	10 transition European countries	ARDL bounds testing approach and the error-correction-based Granger-causality	Causal association amid FDI, export, and economic growth in four states

Source: Authors' work based on existing literature.

2.3. Preceding Examinations on FDI–Institutional Quality Association

The association among institutional factors and FDI is generally defined through its positive or negative consequences, with features such as self-governing organizations, political solidity, and rule of law appealing FDI and issues such as corruption, tax policies and cultural distance discouraging FDI [97]. Dunning [98] postulated that a company requires ownership, location, and internalization benefits to cross borders and engage in FDI. Furthermore, the institutional theory of North [99] highlighted that institutions set out market guidelines, shape connections between economic actors and guarantee that economic arrangements are circumscribed by these directions. However, investors are refractory with reference to states where institutional ambiguities boost bribery, red tape rises the transaction cost of investment, and where the administration can seize investments [100]. Multinational corporations are fascinated by states wherein civil and political independence is valued [101]. Therefore, good quality institutions in the host state are a prerequisite for appealing FDI influxes into that nation [102].

According to Buchanan, Le and Rishi [2], FDI goes to states with better quality institutions, while reduced governance can obstruct FDI. Xu [103] supported that economic freedom of both the homebased state and the host nation are positively associated with FDI. Adversely, Daniele and Marani [104] revealed that crime appears as a disincentive for foreign investors arguing that high levels of crimes are viewed as a signal of a local socio-institutional setting adverse for FDI. Akhtaruzzaman, et al. [105] proved that a one-standard-deviation decrease in seizure risk is related with a 72% rise in FDI. Similarly, Peres, et al. [106] reported for developed states that a one-standard-deviation modification in governance affects FDI by a factor of 0.2225, while the association is not significant for developing countries. By generating ambiguity in investment outcomes and by dropping the anticipated returns, fraud daunts the investment activity of the businesses, which renders into forgone economic growth [107]. The "grease the wheels" hypothesis supported by Kato and Sato [108] advises that corruption can accelerate economic activity under conditions of weak governance structures and ineffective policy. Elheddad [109] underlined that overseas companies choose to invest their money in corrupted extents which let them more admission to the natural resource and reduced taxes. Quite the reverse, the "sand the wheels" hypothesis proved by Meon and Sekkat [110], Cooray and Schneider [111], claims that corruption can be expensive for economic activity. Farla, Crombrugghe and Verspagen [11] did not provide robust evidence of a positive connection amid "good governance" and upper levels of investment but exhibited that the interplay between foreign investment and governance has an adverse mediating consequence on investment.

A brief review of previous papers on the FDI and institutional quality connection is exhibited in Table 3.

Table 3. Earlier studies on FDI and institutional quality.

Author(s)	Time Span	Database	Empirical Methods	Outcomes
Brada, Drabek, Mendez and Perez [15]	2005–2009	43 home countries and 151 host countries	Poisson pseudo maximum-likelihood (PPML) estimation	Fewer FDI in corrupt nations
Dang [112]	2006–2007	60 provinces in Vietnam	Instrumental variable (IV) approach	FDI supports the enhancement of institutions
Asamoah, et al. [113]	1996–2011	40 Sub-Saharan African states	GARCH models	Institutional quality rises the stream of FDI
Buchanan, Le and Rishi [2]	1996–2006	164 nations	OLS regressions	Positive influence of institutional quality on FDI Institutional quality negatively influences the volatility of FDI
Kuzmina, et al. [114]	1895–1914	Russia	OLS and IV-2SLS regressions	Greater incidence of illicit payments, alongside burden from governing organizations, enforcement authorities, and criminals diminish FDI
Busse and Hefeker [115]	1984–2003	83 developing countries	Panel data fixed-effects and GMM regressions	Government stability, internal and external conflict, corruption and ethnic strains, regulation and order, democratic accountability of government, and quality of bureaucracy are drivers of foreign investment inflows
Zakharov [107]	2004–2013	79 Russian regions	Panel data fixed-effects and IV estimation with fixed-effects	Negative association between corruption and the influx of FDI
Adams and Opoku [45]	1980–2011	22 sub-Saharan African states	GMM	Regulation–FDI connections positively influence economic growth
Wisniewski and Pathan [116]	1975–2009	33 OECD members	Pooled OLS, Fixed-effect panel, Two-way fixed-effect panel	Higher FDI are held by states with presidential systems and long democratic tradition
Asiedu and Lien [117]	1982–2007	112 developing countries	GMM	Democracy supports FDI in nations where the portion of natural resources in total exports is reduced, but has a negative influence on FDI in nations where exports are dominated by natural resources
Aziz [118]	1984–2012	16 Arab countries	GMM	Institutional quality measures of economic freedom, ease of doing business and international country risk positively influence FDI influxes
Egger and Winner [20]	1995–1999	73 developed and less developed nations	Fixed effects, Hausman–Taylor, and between regressions	Corruption is an incentive for FDI
Delgado, McCloud and Kumbhakar [40]	1985–2002	60 non-OECD countries	OLS, 2SLS, semiparametric smooth coefficient, nonparametric method of moments models	A 1-point rise in the level of corruption determines a decline of FDI returns between 0.07 and 5.91%
Jude and Levieuge [38]	1984–2009	93 developing countries	Panel smooth regression model	FDI positively influence growth beyond a certain threshold of institutional quality
Zghidi, Mohamed Sghaier and Abida [43]	1980–2013	4 North African countries	System GMM	The outcome of FDI is more prominent when the economic freedom measure occurs
Economou [4]	1996–2017	4 South European states	Random-effects panel data estimations and generalized two-stage least squares (G2SLS) random-effects instrumental variable (IV) regression	Positive influence on FDI related to protection of property rights, government integrity, monetary freedom, and financial freedom
Tintin [5]	1996–2009	6 Central and Eastern European nations	Panel data fixed-effects models	Better institutions entice more FDI influxes
Uddin, et al. [119]	1972–2016	Pakistan	Multivariate OLS regression and VAR system	Democracy rises the inward FDI in the short-run, while a military government has a stronger effect on FDI in the long run

Source: Authors' work based on existing literature.

3. Data and Methodology

3.1. Sample Selection and Variables

The dataset used in this study spans the period from 2003 to 2016, common for all selected measures and comprises 11 Central and Eastern European countries, namely Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia. World Bank and Eurostat databases have been employed to gather the statistical data. The selected variables are listed in Table 4. Throughout the sample period, there is missing data on many variables, which diminish our data set for each model differently. Following preceding studies [2,19,39,41,42,46,57,61], we consider our dependent variable as GDP per capita. In line with earlier studies [2,41,57,61,69], inflows of FDI were considered. Furthermore, we comprise measures set out in the 2030 Agenda for Sustainable Development [48], relating to poverty [13], inequality of income distribution [59,112], education [3,13,20,34,39,41–43,46,52,71,112,118], innovation [14,28,65,104], transport infrastructure [3,13,52,114], information technology [13,28], institutional quality [2,13–15,18–20,28,39,41,42,44,46,52,107,115,117,118]. The estimate of each Worldwide Governance Indicators provides the nation's score on the aggregate indicator, in units of a standard normal distribution, fluctuating from roughly −2.5 to 2.5, with higher values pertaining to better governance. Moreover, country-level control measures are included, namely government expenditure [12,40,42,46,64,71,72,116], urbanization [69], domestic credit to the private sector [41,46,72] and trade [2,5,13,18,19,34,40,42–44,46,52,53,55,61,64,69,72,118].

Table 4. Description of the variables.

Variables	Definitions	Source	Data Availability
	Variables concerning sustainable economic growth		
(1) GROWTH	Gross domestic product per capita (current prices, euro per capita) (log values)	Eurostat (nama_10_pc)	1975–2016
	Variables concerning foreign direct investment		
(2) FDI	Foreign direct investment, net inflows (% of GDP)	World Bank (BX.KLT.DINV.WD.GD.ZS)	1970–2018
	Variables concerning poverty		
(3) POV	Individuals at risk of poverty or social exclusion (percentage)	Eurostat (ilc_peps01)	2003–2016
	Variables concerning the inequality of income distribution		
(4) INEQ	Income quintile share ratio as the ratio of total income received by the 20% of the population with the highest income—top quintile) to that received by the 20% of the population with the lowest income—lowest quintile (percentage)	Eurostat (ilc_di11)	1995–2016
	Variables concerning education		
(5) EDU	Pupils and students as the total number of persons who are enrolled in the regular education system in each country. It covers all levels of education from primary education to postgraduate studies, excluding pre-primary education (log values)	Eurostat (educ_ilev)	1998–2012
	Variables towards innovation		
(6) INNOV	The number of patent applications to the European patent office (log values)	Eurostat (pat_ep_ntot)	1978–2014
	Variables concerning transport infrastructure		
(7) TRANSP	The length of motorways, on the territory of the reporting country (km) (logarithmic values)	Eurostat (ttr00002)	1970–2015
	Variables concerning information technology		
(8) IT	Individuals using the Internet (% of population)	World Bank (IT.NET.USER.ZS)	1960–2017

Table 4. *Cont.*

Variables	Definitions	Source	Data Availability
	Variables concerning institutional quality		
(9) CORR	Control of Corruption Estimate captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests (score)	World Bank (Worldwide Governance Indicators)	1996–2016
(10) GOV_EFF	Government Effectiveness Estimate captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies (score)	World Bank (Worldwide Governance Indicators)	1996–2016
(11) POL_STAB	Political Stability and Absence of Violence/Terrorism Estimate measures perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism (score)	World Bank (Worldwide Governance Indicators)	1996–2016
(12) REG_Q	Regulatory Quality Estimate captures perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private-sector development (score)	World Bank (Worldwide Governance Indicators)	1996–2016
(13) RULE_LAW	Rule of Law Estimate captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence (score)	World Bank (Worldwide Governance Indicators)	1996–2016
(14) VOICE_ACC	Voice and Accountability Estimate captures perceptions of the extent to which a country's citizens can participate in selecting their government, as well as freedom of expression, freedom of association, and a free media (score)	World Bank (Worldwide Governance Indicators)	1996–2016
	Country-level control variables		
(15) GOV_EXP	General government final consumption expenditure (% of GDP)	World Bank (NE.CON.GOVT.ZS)	1960–2018
(16) URB	Urban population (percentage of total)	World Bank (SP.URB.TOTL.IN.ZS)	1960–2016
(17) DCPS	Domestic credit to private sector (percentage of GDP)	World Bank (FS.AST.PRVT.GD.ZS)	1960–2016
(18) TRADE	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product (percentage of GDP)	World Bank (NE.TRD.GNFS.ZS)	1960–2016

Source: Authors' work based on Eurostat and World Bank descriptions.

3.2. Quantitative Techniques

The most common methods identified in the literature concerning the influence of FDI on economic growth are panel data fixed-effects and random-effects estimations [1,2,13,28,41,53,64,65,69,107,114], as well as the generalized method of moments [9,18,41–45,71,72,113,117]. Current paper employs the first approach, the econometric specifications being depicted as follows:

$$GROWTH_{it} = \beta_0 + \beta_1 \times FDI_{it} + \beta_2 \times SDGs_{it} + \beta_3 \times CV_{it} + \varepsilon_{it} \quad (1)$$

$i = 1, 2, \ldots, 11$, $t = 2003, 2004, \ldots, 2016$.

where the dependent variable is GDP per capita in CEECs. *FDI* is a measure of inward FDI flows. *SDGs* signifies a vector of explanatory variables concerning sustainable development goals [48]. *CV* depicts the country-level control variables. β_0 describes the country-specific intercept, β_1–β_3 are the coefficients to be estimated, ε is the error term, i is the subscript of recipient FDI CEE nation, and t is the subscript of time and accounts for the unobservable time-invariant individual specific effect, not included in the regression [34].

Likewise, to inspect for a potential non-linear association between FDI and growth, the squared term of FDI (hereinafter "FDI_SQ") will be encompassed in the aforementioned equation:

$$GROWTH_{it} = \beta_0 + \beta_1 \times FDI_{it} + \beta_2 \times FDI\_SQ_{it} + \beta_3 \times SDGs_{it} + \beta_3 \times CV_{it} + \varepsilon_{it} \quad (2)$$

$i = 1, 2, \ldots, 11$, $t = 2003, 2004, \ldots, 2016$.

The next step is to determine the order of integration. To examine the stationarity of the series, several tests will be performed, such as Augmented Dickey–Fuller (hereinafter "ADF") [1,3,8,14,39,56–58,61,70,73], Phillips–Perron (hereinafter "PP") [1,7,39,58,61,70,73], Levin–Lin–Chu (hereinafter "LLC") [1,13,14,39,70,73,118], Im–Pesaran–Shin (hereinafter "IPS") [1,7,13,14,39,70,73,118] and Breitung [3,39,70,73]. In the ADF and PP tests, the size of the coefficient δ_2 from the further equation should be established [58]:

$$\Delta Z_t = \delta_0 + \delta_1 t + \delta_2 Z_{t-i} + \sum_{i=1}^{n} \beta_i \Delta Z_{t-i} + \varepsilon_t \quad (3)$$

where the variable ΔZ_{t-1} depicts the first differences with n lags. ε_t signifies the variable that adjusts the errors of autocorrelation. The coefficients $\delta_0 - \delta_2$ and β_i are those estimated. The ADF regression checks for the occurrence of unit root of Z_t in all model variables at time t. The null and the alternative hypothesis for the presence of unit root in variable Z_t is depicted below:

$$H_0 \colon \delta_2 = 0 \quad H_1 \colon \delta_2 < 0 \quad (4)$$

Regarding the PP test, the equations and hypotheses are analogous to those of ADF, but the lags of the variables are left out from the models, as follows:

$$\Delta Z_t = \delta_0 + \delta_1 t + \delta_2 Z_{t-i} + \varepsilon_t \quad (5)$$

The LLC test presumes homogeneity in the dynamics of the autoregressive coefficients for all panel members, whereas the IPS test allows heterogeneity in dynamic panel and intertemporal data [1]. Breitung proposes a test statistic that does not apply a biased adjustment whose power is considerably higher than LLC or the IPS tests by means of Monte Carlo trials [70].

Moreover, several panel co-integration tests will be achieved, respectively Pedroni [1,7,39,70], Kao [70] and Fisher-type Johansen [8,56,61,73]. If the variables are cointegrated, there occurs a force that converges into a long-run equilibrium [73]. Pedroni [120] advised the calculation of the regression residuals from the hypothesized cointegrating regression, as below:

$$y_{i,t} = \alpha_i + \delta_i t + \beta_{1i} x_{1i,t} + \beta_{2i} x_{2i,t} + \ldots + \beta_{Mi} x_{Mi,t} + e_{i,t} \quad (6)$$

for $t = 1, \ldots, T$, $i = 1, \ldots, N$, $m = 1, \ldots, M$.

where T denotes the number of observations over time, N signifies the number of individual members in the panel, and M depicts the number of regression variables.

Kao [121] proposed a parametric residual-based panel co-integration, whereas Maddala and Wu [122] suggested the use of Fisher-type panel co-integration test via the methodology of Johansen [123] for the reason that the maximum-likelihood procedure has significantly large and finite sample properties.

After co-integration is settled, the long-run associations will be estimated via Fully Modified Ordinary Least Squares (hereinafter "FMOLS") and Dynamic Ordinary Least Squares (hereinafter "DOLS") in line with prior studies [1,14,39]. The FMOLS estimator produces consistent estimates in small samples and controls for the endogeneity of the regressors and serial correlation, whereas the DOLS estimator removes the second order bias triggered by the fact that the independent variables are endogenous [1]. Therefore, the causal relationships will be established, similar to earlier studies [7,51,58,61,70]. Thus, six tri-variate panel vector error-correction models (hereinafter "PVECM") for investigating the connection between FDI, each institutional quality measure and economic growth will be estimated:

$$(1 - \mathrm{L}) \times \begin{bmatrix} GROWTH_t \\ FDI_t \\ IQ_t \end{bmatrix} = \begin{bmatrix} \alpha_{11} \\ \alpha_{21} \\ \alpha_{31} \end{bmatrix} + \sum_{i=1}^{p} (1 - L) \times \begin{pmatrix} \phi_{1i} & \beta_{1i} & \psi_{1i} \\ \phi_{2i} & \beta_{2i} & \psi_{2i} \\ \phi_{3i} & \beta_{3i} & \psi_{3i} \end{pmatrix} + \begin{bmatrix} \theta \\ \varpi \\ \xi \end{bmatrix} \times ECT_{t-1} + \begin{bmatrix} \eta_{1t} \\ \eta_{2t} \\ \eta_{3t} \end{bmatrix} \quad (7)$$

where IQ denotes the institutional quality variables, $(1 - \mathrm{L})$ depicts the difference operator, ECT_{t-1} signifies the lagged error-correction term that ensues from the long-run cointegrating connection, $\eta_{1t} - \eta_{2t}$ exhibits the white noise serially independent random error terms. The occurrence of a significant association in first differences of the variables reveals the direction of short-run causality, whereas long-run causality is exposed by a significant t-statistic relating to the error-correction term (hereinafter "ECT") [58].

4. Empirical Results and Discussion

4.1. Descriptive Statistics and Correlations

Table 5 reveals the summary statistics for the measures selected in the empirical analysis. The mean level of FDI inflows equaled 5.39% of GDP. Figure 1 shows the temporal evolution of the FDI inflows in CEECs and provides evidence that Slovenia (2.00%) and Lithuania (3.32%) registered the lowest mean values regarding FDI inflows, whereas Bulgaria (8.91%) and Hungary (11.45%) the highest average values. With reference to poverty, we notice that the mean share of individuals at risk of poverty or social exclusion is 29.39%, whereas the average income quintile share ratio is 5.06%. Moreover, a mean value of 35.55% of individuals out of CEECs are using the Internet. Concerning the average values of the variables regarding institutional quality, we notice a poor governance in the CEECs.

The average values of Worldwide Governance Indicators for every selected country are revealed in Figure 2. With reference to control of corruption estimate, the lowest mean values are registered in Romania (−0.21) and Bulgaria (−0.15), whereas the highest mean values in Slovenia (0.90) and Estonia (1.06). Government effectiveness estimate shows the bottom mean figures in Romania (−0.23) and Bulgaria (0.12), but the uppermost mean figures in Slovenia (1.014) and Estonia (1.015). Regarding political stability and absence of violence/terrorism estimate, the lowest mean values are reported in Romania (0.20) and Bulgaria (0.24), while the highest mean values are exhibited in the Czech Republic

(0.98) and Slovenia (1.03). Regulatory quality estimate reveals the lowest average numbers in Romania (0.45) and Croatia (0.47), while the highest average numbers in the Czech Republic (1.13) and Estonia (1.43). Relating to the rule of law estimate, Bulgaria (−0.08) and Romania (0.004) shows the lowest mean values, whereas Slovenia (0.99) and Estonia (1.12) point out the highest mean values. In terms of voice and accountability estimate, Romania (0.42) and Bulgaria (0.51) displays the lowest average figures, but then again Slovenia (1.05) and Estonia (1.10) the highest mean figures.

Table 5. Descriptive statistics (raw data).

Variables	Obs.	Mean	Std. Dev.	Min	Max
(1) GROWTH	230	8310.43	4407.87	1000.00	19600.00
(2) FDI	209	5.39	7.07	−15.99	54.84
(3) POV	125	29.39	10.22	13.30	61.30
(4) INEQ	146	5.06	1.39	3.00	8.30
(5) EDU	160	1950.91	2353.90	237.60	9153.10
(6) INNOV	250	58.55	86.03	0.50	609.16
(7) TRANSP	280	422.50	364.20	0.00	1883.90
(8) IT	263	35.55	28.75	0.00	87.24
(9) CORR	165	0.36	0.39	−0.44	1.30
(10) GOV_EFF	165	0.64	0.39	−0.36	1.19
(11) POL_STAB	165	0.69	0.31	0.00	1.30
(12) REG_Q	165	0.90	0.31	−0.04	1.70
(13) RULE_LAW	165	0.60	0.41	−0.26	1.37
(14) VOICE_ACC	165	0.83	0.25	0.30	1.20
(15) GOV_EXP	209	18.92	1.95	12.37	25.88
(16) URB	297	62.93	7.59	49.63	75.22
(17) DCPS	256	42.77	20.57	0.19	101.29
(18) TRADE	271	105.27	34.63	39.14	184.55

Source: Authors' computations. Notes: For the definition of variables, please see Table 4.

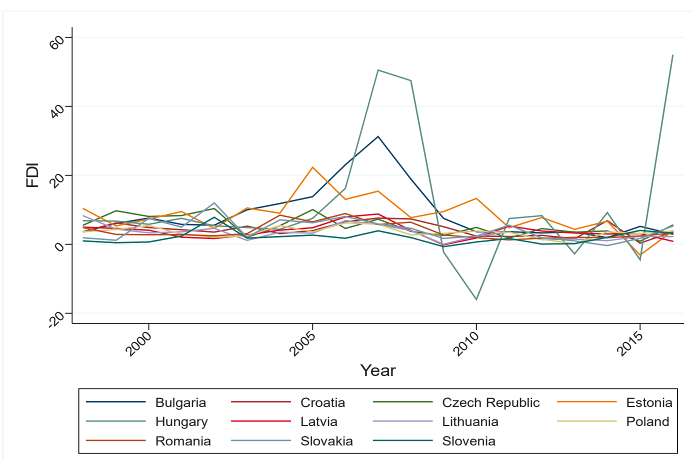

Figure 1. The evolution of FDI in CEECs. Source: Authors' work. Notes: For the definition of variables, please see Table 4.

In line with prior studies [2,4,5,46,55,72,73,112,115,116,118,119], the correlation coefficients of the selected measures are reported in Table 6. We ascertain high level of correlation amid institutional dimensions as in previous studies [2,4,13,23,28]. Therefore, to get rid of the multicollinearity issue, the highly correlated measures will be included in separate regression models.

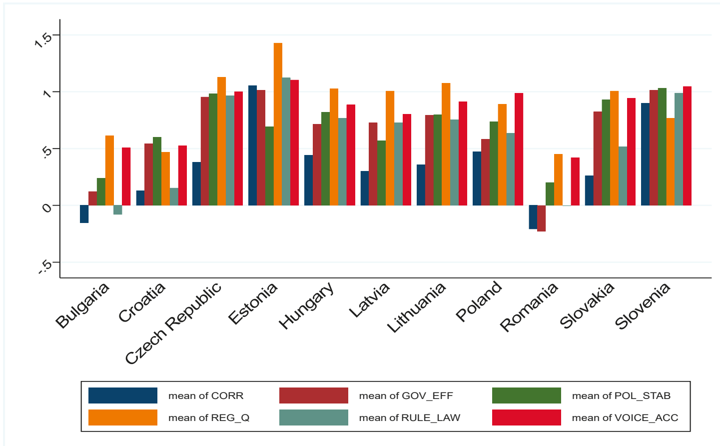

Figure 2. Worldwide Governance Indicators (mean values) in CEECs. Source: Authors' work. Notes: For the definition of variables, please see Table 4.

Table 6. Correlation matrix.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) GROWTH	1								
(2) FDI	−0.11	1							
(3) POV	−0.89***	0.13	1						
(4) INEQ	−0.33***	−0.02	0.74***	1					
(5) EDU	−0.23**	−0.03	0.23*	−0.08	1				
(6) INNOV	0.64***	−0.04	−0.41***	−0.50***	0.40***	1			
(7) TRANSP	0.23***	0.01	−0.23*	−0.46***	0.37***	0.46***	1		
(8) IT	0.83***	−0.04	−0.62***	0.02	−0.27***	0.52***	0.09	1	
(9) CORR	0.61***	−0.01	−0.62***	−0.32***	−0.45***	0.27**	−0.02	0.40***	1
(10) GOV_EFF	0.72***	−0.09	−0.78***	−0.49***	−0.50***	0.24**	−0.05	0.53***	0.80***
(11) POL_STAB	0.55***	-0.08	−0.76***	−0.73***	−0.19*	0.35***	0.18*	0.23**	0.57***
(12) REG_Q	0.42***	0.06	−0.44***	−0.11	−0.32***	0.13	−0.21*	0.42***	0.68***
(13) RULE_LAW	0.72***	−0.03	−0.73***	−0.38***	−0.37***	0.35***	−0.12	0.56***	0.86***
(14) VOICE_ACC	0.53***	−0.05	−0.70***	−0.46***	−0.20*	0.35***	−0.01	0.32***	0.84***
(15) GOV_EXP	−0.06	0.06	−0.50***	−0.56***	−0.16*	−0.01	0.05	−0.16*	0.33***
(16) URB	−0.23***	0.24***	0.18*	0.22**	−0.08	−0.02	−0.21***	0.06	−0.03
(17) DCPS	0.60***	0.03	−0.09	0.13	−0.47***	0.26***	0.03	0.64***	0.34***
(18) TRADE	0.51***	0.14*	−0.48***	−0.34***	−0.46***	0.29***	0.1	0.67***	0.40***
Variables	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**	**(15)**	**(16)**	**(17)**	**(18)**
(10) GOV_EFF	1								
(11) POL_STAB	0.74***	1							
(12) REG_Q	0.70***	0.46***	1						
(13) RULE_LAW	0.87***	0.65***	0.80***	1					
(14) VOICE_ACC	0.82***	0.73***	0.79***	0.88***	1				
(15) GOV_EXP	0.52***	0.51***	0.32***	0.41***	0.44***	1			
(16) URB	0.12	−0.09	0.44***	0.17*	0.08	0.24***	1		
(17) DCPS	0.34***	0.02	0.22**	0.33***	0.14†	−0.06	0.12†	1	
(18) TRADE	0.57***	0.42***	0.52***	0.53***	0.45***	0.11†	0.18**	0.42***	1

Source: Authors' computations. Notes: Superscripts ***, **, *, and † indicate statistical significance at 0.1%, 1%, 5%, and 10% respectively. For the definition of variables, please see Table 4.

4.2. Multivariate Analysis Outcomes

The Hausman test was accomplished for all the estimated econometric models and most of the outcomes support that panel data fixed-effects estimators are consistent than panel data random effects, as in Kayalvizhi and Thenmozhi [28]. However, Zakharov [107] contended that fixed-effects regressions eliminate time-invariant factors typical for each country and comprise time dummies to catch the common time trend.

Table 7 reports the results of estimations concerning the impact of FDI, poverty, and income inequality on growth. The estimated coefficient of FDI is negative in (1), revealing a low statistical significance, while statistically insignificant in (3). However, in (2) and (4), the coefficient of FDI is also negative, but the coefficient of FDI_SQ is positive, therefore showing a non-linear relationship with GDP per capita. The non-linear relationship between FDI and growth is in line with prior studies [37,66–68]. Furthermore, individuals at risk of poverty or social exclusion show a negative impact on economic growth, in estimations (1) and (2), since poverty act against human capital expansion through restraining the capacity of people to go on healthy and to contribute via talented workforce. On the contrary, estimations (3) and (4) show that income quintile share ratio positively influences economic growth, similar to Fawaz, Rahnama and Valcarcel [30].

Table 7. The outcomes of panel data regression models towards the influence of FDI, poverty, and income inequality on economic growth.

Variables	(1)		(2)		(3)		(4)	
	FE	RE	FE	RE	FE	RE	FE	RE
FDI	−0.00† (−1.78)	−0.00† (−1.90)	−0.01* (−2.08)	−0.01** (−3.26)	−0.00 (−0.81)	−0.00 (−0.89)	−0.01* (−2.07)	−0.01* (−2.21)
FDI_SQ			0.00 (1.50)	0.00** (2.60)			0.00† (1.90)	0.00* (2.02)
INEQ					0.07** (2.88)	0.06** (2.68)	0.08** (3.21)	0.07** (2.98)
POV	−0.02*** (−10.28)	−0.02*** (−10.83)	−0.02*** (−9.82)	−0.03*** (−15.82)				
GOV_EXP	0.02 (1.57)	0.01 (1.22)	0.01 (1.25)	0.00 (0.22)	−0.01 (−0.36)	−0.01 (−0.39)	−0.01 (−0.77)	−0.01 (−0.66)
URB	−0.02† (−1.76)	−0.01* (−2.52)	−0.03* (−2.03)	−0.01** (−3.12)	−0.01 (−0.34)	−0.02* (−2.00)	−0.01 (−0.91)	−0.02* (−2.03)
DCPS	0.00 (0.68)	0.00 (1.26)	0.00 (0.65)	0.00*** (3.91)	0.01*** (9.00)	0.01*** (8.95)	0.01*** (9.05)	0.01*** (9.08)
TRADE	0.01*** (8.53)	0.01*** (7.83)	0.01*** (8.04)	0.00** (3.06)	0.01*** (9.19)	0.01*** (9.88)	0.01*** (8.26)	0.01*** (9.10)
_cons	10.31*** (10.77)	9.80*** (26.05)	10.63*** (10.90)	10.03*** (50.77)	7.57*** (6.88)	8.36*** (13.36)	8.37*** (7.17)	8.58*** (12.77)
F statistic	49.64***		43.37***		64.39***		56.87***	
R-sq. within	0.74	0.73	0.74	0.60	0.76	0.75	0.76	0.76
Hausman test Prob>chi2	0.0266		0.0000		0.0186		0.0945	
Obs.	123.00	123.00	123.00	123.00	142.00	142.00	142.00	142.00
N Countries	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00

Source: Authors' computations. Notes: Superscripts ***, **, *, and † indicate statistical significance at 0.1%, 1%, 5%, and 10% respectively. Figures in brackets show t-statistic. FE denotes fixed-effects (within) regression. RE denotes Random-effects Generalized Least Squares (GLS) regression. For the definition of variables, please see Table 4.

Table 8 presents the estimation outcomes regarding the influence of FDI, education, and innovation on economic growth. The estimation results display the lack of any statistically significant relationship between FDI and growth in all the estimated models. On the other hand, the coefficients of pupils and students, in estimations (1) and (2), alongside the number of patent applications, in estimations (3) and (4), are positive and statistically significant. In fact, educational attainment would catch the absorptive capacity of the economy [46]. This implies that enhanced human capital formation, alongside innovation boost GDP per capita.

The outcomes of panel data regression models towards the impact of FDI, transport infrastructure, and information technology on economic growth are illustrated in Table 9. Analogous to the outcomes from Table 8, there is not found any statistically significant association between FDI and GDP per capita. As well, the coefficients of transport infrastructure in (1) and (2) and information technology in (3) and (4) shows a positive influence on economic growth. Nevertheless, better infrastructure rises the productivity of investment and thus spurs FDI flows [29].

Table 8. The outcomes of panel data regression models towards the influence of FDI, education, and innovation on economic growth.

Variables	(1)		(2)		(3)		(4)	
	FE	RE	FE	RE	FE	RE	FE	RE
FDI	−0.00 (−0.16)	−0.00 (−0.71)	−0.00 (−0.51)	−0.00 (−0.68)	0.00 (0.23)	−0.00 (−0.19)	0.00 (0.07)	−0.00 (−0.30)
FDI_SQ			0.00 (0.50)	0.00 (0.41)			0.00 (0.04)	0.00 (0.27)
EDU	−0.77* (−2.15)	0.03 (0.35)	−0.78* (−2.16)	0.02 (0.16)				
INNOV					0.23*** (7.13)	0.21*** (7.65)	0.23*** (7.08)	0.21*** (7.51)
GOV_EXP	−0.04** (−3.03)	−0.03* (−2.51)	−0.04** (−3.06)	−0.04** (−2.61)	−0.02† (−1.91)	−0.02† (−1.92)	−0.02† (−1.89)	−0.02* (−1.99)
URB	−0.03 (−1.38)	−0.02* (−2.12)	−0.03 (−1.45)	−0.02* (−2.03)	0.01 (0.80)	−0.01 (−1.37)	0.01 (0.78)	−0.01 (−1.13)
DCPS	0.01*** (7.53)	0.01*** (10.25)	0.01*** (7.47)	0.01*** (10.14)	0.01*** (8.06)	0.01*** (9.15)	0.01*** (8.03)	0.01*** (9.03)
TRADE	0.01*** (6.80)	0.01*** (8.60)	0.01*** (6.62)	0.01*** (8.42)	0.01*** (6.28)	0.01*** (7.04)	0.01*** (6.21)	0.01*** (6.86)
_cons	15.49*** (5.34)	9.15*** (9.09)	15.73*** (5.34)	9.36*** (8.48)	6.71*** (6.64)	8.07*** (15.87)	6.72*** (6.47)	8.03*** (14.63)
F statistic	73.42***		62.62***		131.10***		111.67***	
R-sq. within	0.76	0.75	0.76	0.75	0.83	0.83	0.83	0.83
Hausman test Prob>chi2	0.0142		0.0521		0.0100		0.0472	
Obs.	154.00	154.00	154.00	154.00	177.00	177.00	177.00	177.00
N Countries	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00

Source: Authors' computations. Notes: Superscripts ***, **, *, and † indicate statistical significance at 0.1%, 1%, 5%, and 10% respectively. Figures in brackets show t-statistic. FE denotes fixed-effects (within) regression. RE denotes Random-effects Generalized Least Squares (GLS) regression. For the definition of variables, please see Table 4.

Table 9. The outcomes of panel data regression models towards the influence of FDI, transport infrastructure, and information technology on economic growth.

Variables	(1)		(2)		(3)		(4)	
	FE	RE	FE	RE	FE	RE	FE	RE
FDI	−0.00 (−0.82)	−0.00 (−1.22)	−0.00 (−0.70)	−0.01 (−1.13)	−0.00 (−0.01)	−0.00 (−0.08)	−0.00 (−0.00)	0.00 (0.14)
FDI_SQ			0.00 (0.35)	0.00 (0.59)			−0.00 (−0.00)	−0.00 (−0.19)
TRANSP	0.29*** (5.45)	0.12*** (3.60)	0.29*** (5.34)	0.12*** (3.40)				
IT					0.01*** (16.14)	0.01*** (15.96)	0.01*** (15.91)	0.01*** (15.84)
GOV_EXP	−0.06*** (−5.09)	−0.05*** (−4.05)	−0.06*** (−5.08)	−0.05*** (−4.03)	−0.05*** (−5.97)	−0.04*** (−5.44)	−0.05*** (−5.90)	−0.04*** (−5.51)
URB	−0.06*** (−3.74)	−0.02* (−2.33)	−0.06*** (−3.74)	−0.02* (−2.34)	−0.03** (−3.32)	−0.02** (−3.14)	−0.03** (−3.21)	−0.02** (−3.07)
DCPS	0.01*** (9.46)	0.01*** (10.43)	0.01*** (9.43)	0.01*** (10.40)	0.00*** (3.82)	0.00*** (3.97)	0.00*** (3.80)	0.00*** (3.92)
TRADE	0.01*** (9.07)	0.01*** (10.64)	0.01*** (8.88)	0.01*** (10.39)	−0.00 (−0.02)	0.00 (0.46)	−0.00 (−0.01)	0.00 (0.38)
_cons	10.70*** (11.21)	9.00*** (13.85)	10.76*** (11.05)	9.04*** (14.00)	10.95*** (17.83)	10.35*** (20.86)	10.95*** (17.04)	10.42*** (19.60)
F statistic	123.35***		105.21***		306.61***		261.38***	
R-sq. within	0.81	0.80	0.81	0.80	0.91	0.91	0.91	0.91

Table 9. *Cont.*

Variables	(1)		(2)		(3)		(4)	
	FE	RE	FE	RE	FE	RE	FE	RE
Hausman test Prob>chi2	0.0006		0.0011		0.1073		0.2950	
Obs.	189.00	189.00	189.00	189.00	201.00	201.00	201.00	201.00
N Countries	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00

Source: Authors' computations. Notes: Superscripts ***, **, *, and † indicate statistical significance at 0.1%, 1%, 5%, and 10% respectively. Figures in brackets show t-statistic. FE denotes fixed-effects (within) regression. RE denotes Random-effects Generalized Least Squares (GLS) regression. For the definition of variables, please see Table 4.

Tables 10 and 11 show the estimation outcomes regarding the impact of FDI and institutional quality on economic growth. Similar to Table 7, the results of panel data fixed-effects regression models provide evidence for a non-linear link with economic growth. Furthermore, all the Worldwide Governance Indicators positively influence growth, except political stability and absence of violence/terrorism which is not statistically significant. In case of control of corruption, the "helping hand" viewpoint [18–20] is confirmed. Similar to Kato and Sato [108], the "grease the wheels" hypothesis is established. As well, consistent with Iamsiraroj [46], quality of institutions exerts a critical role in augmenting economic growth directly and through FDI inflows.

Table 10. The outcomes of panel data regression models towards the influence of FDI, control of corruption, government effectiveness, political stability and absence of violence/terrorism on economic growth.

Variables	(1)		(2)		(3)		(4)		(5)		(6)	
	FE	RE	FE	RE	FE	RE	FE	RE	FE	RE	FE	RE
FDI	−0.00 (−1.49)	−0.00† (−1.83)	−0.01* (−2.24)	−0.01** (−3.04)	−0.00 (−0.76)	−0.00 (−1.14)	−0.01† (−1.84)	−0.01** (−2.70)	−0.00 (−1.65)	−0.00† (−1.73)	−0.01* (−2.21)	−0.01* (−2.42)
FDI_SQ			0.00† (1.78)	0.00* (2.50)			0.00† (1.67)	0.00* (2.45)			0.00† (1.68)	0.00† (1.86)
CORR	0.48*** (4.56)	0.38*** (4.40)	0.48*** (4.59)	0.40*** (4.69)								
GOV_EFF					0.54*** (4.55)	0.48*** (5.00)	0.54*** (4.53)	0.50*** (5.12)				
POL_STAB									−0.02 (−0.22)	0.11 (1.20)	−0.03 (−0.29)	0.09 (0.98)
GOV_EXP	−0.03* (−2.42)	−0.04** (−2.70)	−0.04** (−2.73)	−0.04** (−3.16)	−0.03* (−2.21)	−0.04** (−3.25)	−0.04* (−2.51)	−0.05*** (−3.56)	−0.04** (−2.72)	−0.03* (−2.23)	−0.05** (−3.01)	−0.04** (−2.58)
URB	0.03 (1.64)	−0.01† (−1.83)	0.02 (1.18)	−0.01 (−1.61)	0.02 (1.39)	−0.01† (−1.85)	0.02 (0.94)	−0.01 (−1.63)	−0.00 (−0.28)	−0.01† (−1.94)	−0.01 (−0.70)	−0.01† (−1.80)
DCPS	0.01*** (9.10)	0.01*** (8.36)	0.01*** (9.17)	0.01*** (8.64)	0.01*** (8.64)	0.01*** (8.54)	0.01*** (8.70)	0.01*** (8.74)	0.01*** (8.56)	0.01*** (8.36)	0.01*** (8.61)	0.01*** (8.50)
TRADE	0.01*** (8.44)	0.01*** (8.57)	0.01*** (7.65)	0.01*** (7.77)	0.01*** (7.94)	0.01*** (7.58)	0.01*** (7.20)	0.01*** (6.89)	0.01*** (7.83)	0.01*** (8.94)	0.01*** (7.07)	0.01*** (8.19)
_cons	6.46*** (5.48)	8.95*** (20.46)	7.08*** (5.80)	9.09*** (19.59)	6.60*** (5.64)	9.06*** (18.82)	7.20*** (5.92)	9.17*** (17.44)	8.76*** (7.27)	8.95*** (17.86)	9.41*** (7.47)	9.15*** (16.62)
F statistic	62.17***		54.54***		62.11***		54.30***		51.42***		45.02***	
R-sq. within	0.72	0.71	0.72	0.72	0.72	0.71	0.72	0.72	0.68	0.67	0.68	0.68
Hausman test Prob>chi2	0.0000		0.0004		0.0008		0.0121		0.0001		0.0015	
Obs.	163.00	163.00	163.00	163.00	163.00	163.00	163.00	163.00	163.00	163.00	163.00	163.00
N Countries	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00

Source: Authors' computations. Notes: Superscripts ***, **, *, and † indicate statistical significance at 0.1%, 1%, 5%, and 10% respectively. Figures in brackets show t-statistic. FE denotes fixed-effects (within) regression. RE denotes Random-effects Generalized Least Squares (GLS) regression. For the definition of variables, please see Table 4.

With reference to country-level control measures, general government final consumption expenditure negatively influences economic growth. Iamsiraroj [46] claimed that FDI may relocate domestic saving, whereas Awad and Ragab [42] reinforced for developing states where inland sources of capital are inadequate that private-sector investment may be “crowded out” by higher levels of government spending. Urban population negatively influences economic growth, similar to some extent to Alvarado, Iñiguez and Ponce [69], but contrary to Henderson [33] which claimed that urbanization accelerates growth. Domestic credit to private sector exerts a positive influence on growth similar to Feeny, Iamsiraroj and McGillivray [41]. Trade shows a positive effect on economic growth since openness empowers a more efficient manufacture of goods and services through moving production to nations that have an inclusive benefit [46]. As such, more openness to trade determines a higher FDI influxes, thus showing a positive influence on growth.

Table 11. The outcomes of panel data regression models towards the influence of FDI, regulatory quality, rule of law, voice, and accountability on economic growth.

Variables	1		2		3		4		5		6	
	FE	RE	FE	RE	FE	RE	FE	RE	FE	RE	FE	RE
FDI	−0.00 (−1.24)	−0.00 (−1.62)	−0.01† (−1.68)	−0.01** (−2.79)	−0.00† (−1.68)	−0.00† (−1.91)	−0.01† (−1.96)	−0.01** (−3.18)	−0.00 (−1.38)	−0.00† (−1.70)	−0.01* (−2.21)	−0.01** (−2.91)
FDI_SQ			0.00 (1.29)	0.00* (2.32)			0.00 (1.39)	0.00** (2.59)			0.00† (1.79)	0.00* (2.41)
REG_Q	0.88*** (8.86)	0.65*** (6.89)	0.87*** (8.73)	0.68*** (7.30)								
RULE_LAW					0.87*** (8.22)	0.67*** (7.89)	0.86*** (8.12)	0.67*** (8.22)				
VOICE_ACC									0.62** (3.08)	0.38** (2.73)	0.63** (3.14)	0.44** (3.07)
GOV_EXP	−0.02 (−1.45)	−0.04** (−3.02)	−0.02† (−1.69)	−0.04** (−3.27)	−0.04** (−3.09)	−0.05*** (−4.12)	−0.04** (−3.31)	−0.05*** (−4.33)	−0.03* (−2.31)	−0.04** (−2.87)	−0.04** (−2.62)	−0.05*** (−3.33)
URB	0.03* (2.26)	−0.02* (−2.21)	0.03† (1.83)	−0.02* (−1.98)	0.04** (2.62)	−0.01* (−2.52)	0.03* (2.17)	−0.01** (−2.86)	0.04† (1.83)	−0.01 (−1.49)	0.03 (1.49)	−0.01 (−1.21)
DCPS	0.01*** (8.10)	0.01*** (8.38)	0.01*** (8.15)	0.01*** (8.49)	0.01*** (6.37)	0.01*** (7.07)	0.01*** (6.43)	0.01*** (7.12)	0.01*** (8.46)	0.01*** (8.47)	0.01*** (8.52)	0.01*** (8.65)
TRADE	0.01*** (11.92)	0.01*** (10.55)	0.01*** (11.03)	0.01*** (9.95)	0.01*** (7.65)	0.01*** (7.16)	0.01*** (7.03)	0.01*** (6.39)	0.01*** (8.75)	0.01*** (9.03)	0.01*** (8.02)	0.01*** (8.23)
_cons	5.15*** (5.11)	8.74*** (16.37)	5.59*** (5.27)	8.79*** (15.23)	5.89*** (5.84)	9.40*** (23.20)	6.36*** (6.00)	9.59*** (24.78)	5.35*** (3.45)	8.73*** (16.67)	5.95*** (3.78)	8.82*** (15.41)
F statistic	92.07***		79.51***		86.42***		74.83***		56.32***		49.47***	
R-sq. within	0.79	0.77	0.79	0.78	0.78	0.76	0.78	0.77	0.70	0.69	0.70	0.70
Hausman testProb>chi2	0.0000		0.0002		0.0000		0.0000		0.0002		0.0062	
Obs.	163.00	163.00	163.00	163.00	163.00	163.00	163.00	163.00	163.00	163.00	163.00	163.00
N Countries	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00

Source: Authors’ computations. Notes: Superscripts ***, **, *, and † indicate statistical significance at 0.1%, 1%, 5%, and 10% respectively. Figures in brackets show t-statistic. FE denotes fixed-effects (within) regression. RE denotes Random-effects Generalized Least Squares (GLS) regression. For the definition of variables, please see Table 4.

4.3. Causality Analysis

Tables 12 and 13 summarize the panel unit root tests, both for the variables in level and first difference, for types concerning individual intercept, as well as individual intercept and trend, to ensure more robustness. Since all the variables are highly statistically significant at first difference, we notice that all measures are integrated of order one I (1). Thus, we might expect there is a long-run connection between these variables together [109].

Table 14 summarizes the results of panel co-integration examination among the variables using the Pedroni statistics. For the first model, one out of seven Pedroni tests rejects the null hypothesis of no co-integration by means of both the panel and group forms of the Phillips–Perron and ADF tests. Onward, four statistics confirm the co-integration for the second model, three statistics for the third model, two statistics for the fourth model and the sixth models, while six statistics for the fifth model.

Table 12. Unit root checking for variables in level.

Variables	Level								
	Individual Intercept				Individual Intercept and Trend				
	LLC	IPS	ADF	PP	LLC	Breitung	IPS	ADF	PP
(1) GROWTH	−6.89148***	−2.83747**	42.1514**	58.4211***	0.15541	3.17011	3.01311	6.73929	6.39581
(2) FDI	−5.13076***	−4.58253***	60.6361***	56.5393***	−3.87191***	−3.2594***	−3.62251***	50.3541***	56.1099***
(3) POV	−6.30543***	−3.14041***	50.1233***	54.6683***	−6.45945***	−2.33002**	−2.18696*	46.6079**	43.2553**
(4) INEQ	−14.2876***	−5.9795***	68.0805***	73.5803***	−13.3524***	−2.57474**	−5.04005***	67.067***	103.905***
(5) EDU	−14.2876***	−5.9795***	68.0805***	73.5803***	−3.96935***	3.58804	0.23805	26.7064	38.9658*
(6) INNOV	−4.17114***	−0.5406	40.3984**	29.4974	−2.45073**	−1.68113*	−5.10344***	64.2222***	92.981***
(7) TRANSP	0.16593	4.22876	6.54	6.06803	−0.71733	0.48229	0.15573	18.54	17.4855
(8) IT	2.38744	6.07589	2.12261	2.14089	−0.22001	−0.13088	0.75325	15.7589	12.7974
(9) CORR	0.09776	0.63304	18.3063	19.7321	−0.94174	−0.23127	−0.7865	26.3428	33.0795†
(10) GOV_EFF	−2.08343*	−2.51437**	42.9291**	54.336***	−2.83903**	−1.23925	−1.9375*	35.1402*	42.4099**
(11) POL_STAB	−6.14953***	−4.35309***	55.5461***	58.6936***	−2.90664**	−0.53716	−0.39607	22.4669	44.5648**
(12) REG_Q	−1.54727†	0.1684	24.2968	18.8836	−3.49729***	0.06775	−1.13672	25.5891	26.3469
(13) RULE_LAW	−0.63316	0.33652	23.3193	28.4594	−2.75257**	−0.76952	−2.86205**	41.8436**	64.9622***
(14) VOICE_ACC	0.95339	−0.01605	30.1553	20.4843	−2.76689**	1.17876	−1.59179†	31.3506†	26.7416
(15) GOV_EXP	−3.28222***	−3.0214**	45.7265**	46.235**	−4.47912***	−1.52291†	−3.49884***	48.2018**	36.4402*
(16) URB	2.34336	2.73388	19.8265	43.537**	−2.42386**	−3.03075**	0.44016	23.0641	7.86373
(17) DCPS	−3.17298***	−1.36901†	33.1668†	15.3335	2.36018	1.14294	1.30803	10.6243	6.93452
(18) TRADE	−0.57095	1.36231	12.4385	12.6113	−2.17451*	−3.09165**	−2.91162**	43.1445**	37.8771*

Source: Authors' computations. Notes: lag lengths are determined via Schwarz Info Criterion. Superscripts ***, **, * and † indicate statistical significance at 0.1%, 1%, 5% and 10% respectively. LLC reveals Levin, Lin and Chu t* stat. Breitung reveals Breitung t-stat. IPS reveals Im, Pesaran, and Shin W-stat. ADF reveals Augmented Dickey–Fuller Fisher Chi-square. PP reveals Phillips–Perron Fisher Chi-square. LLC and Breitung assumes common unit root process. IPS, ADF, and PP assumes individual unit root process. Probabilities for ADF and PP are computed using an asymptotic Chi-square distribution. Probabilities for the LLC, Breitung, and IPS tests are computed assuming asymptotic normality. For the definition of variables, please see Table 4.

Table 13. Unit root checking for variables in first difference.

Variables	First Difference								
	Individual Intercept				Individual Intercept and Trend				
	LLC	IPS	ADF	PP	LLC	Breitung	IPS	ADF	PP
(1) ΔGROWTH	−10.0412***	−7.1558***	91.0021***	81.29***	−11.2039***	−6.56351***	−7.06473***	85.2992***	88.9451***
(2) ΔFDI	−12.6609***	−12.4626***	156.28***	452.106***	−9.6859***	−5.18914***	−9.20536***	108.654***	154.953***
(3) ΔPOV	−5.32266***	−3.19925***	47.048**	52.9729***	−4.40028***	−1.41804†	−0.20066	24.1753	25.6106
(4) ΔINEQ	−15.3118***	−11.1358***	124.86***	138.282***	−11.078***	−1.97373*	−4.45331***	79.4281***	121.825***
(5) ΔEDU	−2.61974**	−0.87694	30.1715	35.3114*	−3.47777***	−0.0883	−0.39812	29.8188	37.1392*
(6) ΔINNOV	−14.9716***	−16.306***	214.13***	389.426***	−14.4802***	−7.34945***	−17.1801***	210.228***	528.752***
(7) ΔTRANSP	−10.5123***	−10.3428***	127.778***	127.185***	−8.72964***	−8.15695***	−8.93238***	104.849***	114.023***
(8) ΔIT	−5.79754***	−5.57405***	72.5568***	85.062***	−5.04762***	−5.30682***	−3.84183***	53.1043***	59.786***
(9) ΔCORR	−8.05233***	−7.09242***	86.6963***	95.5046***	−5.96343***	−1.90304*	−4.0105***	54.3082***	85.6108***
(10) ΔGOV_EFF	−12.8263***	−10.5067***	123.252***	129.783***	−11.0076***	−4.84495***	−8.46448***	94.4206***	121.1***
(11) ΔPOL_STAB	−10.09***	−8.19166***	98.6169***	125.865***	−8.98325***	−3.30695***	−6.80943***	82.317***	146.228***
(12) ΔREG_Q	−8.07981***	−7.17869***	88.8002***	96.2212***	−9.70664***	−2.96341**	−6.76272***	77.9188***	94.6873***
(13) ΔRULE_LAW	−8.40469***	−8.13053***	96.3068***	122.676***	−8.32379***	0.5883	−5.85384***	69.9895***	85.7716***
(14) ΔVOICE_ACC	−9.90439***	−8.19117***	99.3145***	130.447***	−10.1777***	−4.93672***	−7.52055***	84.7466***	123.706***
(15) ΔGOV_EXP	−11.3765***	−9.19058***	113.171***	341.109***	−8.91053***	−7.43709***	−7.01183***	82.334***	114.625***
(16) ΔURB	3.37016	−0.68492	50.8643***	46.8744**	1.10092	−1.93539*	−3.49968***	59.7389***	87.0832***
(17) ΔDCPS	−5.83659***	−6.26303***	81.0564***	84.8147***	−4.11108***	2.08777	−4.16056***	61.1824***	64.09***
(18) ΔTRADE	−12.5416***	−10.9456***	141.017***	166.151***	−10.6513***	−8.69885***	−8.84618***	104.826***	129.987***

Source: Authors' computations. Notes: lag lengths are determined via Schwarz Info Criterion. Superscripts ***, **, * and † indicate statistical significance at 0.1%, 1%, 5% and 10% respectively. LLC reveals Levin, Lin and Chu t* stat. Breitung reveals Breitung t-stat. IPS reveals Im, Pesaran, and Shin W-stat. ADF reveals Augmented Dickey–Fuller Fisher Chi-square. PP reveals Phillips–Perron Fisher Chi-square. LLC and Breitung assumes common unit root process. IPS, ADF, and PP assumes individual unit root process. Probabilities for ADF and PP are computed using an asymptotic Chi-square distribution. Probabilities for the LLC, Breitung, and IPS tests are computed assuming asymptotic normality. For the definition of variables, please see Table 4.

Table 14. The outcome of Pedroni (Engle Granger-based) panel co-integration test.

Models		Co-integration Test Null Hypothesis: No Co-integration	Individual Intercept		Individual Intercept and Individual Trend		No Intercept or Trend	
			Statistic	Weighted Statistic	Statistic	Weighted Statistic	Statistic	Weighted Statistic
(1)	GROWTH FDI CORR	Panel v-Statistic	−1.7076	−1.5416	2.558375**	2.358355**	−2.5585	−2.5629
		Panel rho-Statistic	1.7729	1.6675	2.9389	2.5653	0.6379	1.0724
		Panel PP-Statistic	0.8394	0.6747	2.4321	1.5509	−0.0228	0.6954
		Panel ADF-Statistic	−0.1785	−0.2901	0.0185	−0.1417	−0.1750	0.6009
		Group rho-Statistic	3.2381		3.3607		2.0779	
		Group PP-Statistic	1.4325		1.2245		0.5920	
		Group ADF-Statistic	−0.0656		−0.3940		0.0036	
(2)	GROWTH FDI GOV_EFF	Panel v-Statistic	−2.0410	−1.8150	5.601757***	3.009423**	−2.5340	−2.5525
		Panel rho-Statistic	1.6788	1.4922	2.3794	2.1078	−0.0905	0.4903
		Panel PP-Statistic	0.4617	0.3585	1.4419	0.7355	−1.2721	−0.8283
		Panel ADF-Statistic	0.2270	−0.0464	0.7036	0.2789	−1.337236†	−0.8235
		Group rho-Statistic	2.6590		3.1500		0.5467	
		Group PP-Statistic	1.0769		1.5894		−2.457101**	
		Group ADF-Statistic	0.3420		0.8662		−2.806141**	
(3)	GROWTH FDI POL_STAB	Panel v-Statistic	−1.9435	−1.7911	4.109299***	3.148275***	−2.5467	−2.5509
		Panel rho-Statistic	1.6581	1.4842	2.8441	2.5303	0.7844	0.4696
		Panel PP-Statistic	0.8934	0.4409	1.6648	0.8465	0.2732	−0.6228
		Panel ADF-Statistic	0.8873	0.3311	1.3484	0.5390	0.2050	−0.7181
		Group rho-Statistic	2.8741		3.5536		1.1195	
		Group PP-Statistic	1.2001		1.5957		−1.88605*	
		Group ADF-Statistic	0.9912		0.9094		−2.142891*	
(4)	GROWTH FDI REG_Q	Panel v-Statistic	−1.9322	−1.7904	3.827421***	3.100601**	−2.5047	−2.5344
		Panel rho-Statistic	1.7994	1.8637	2.4795	2.2650	0.0694	0.7520
		Panel PP-Statistic	0.4580	0.6717	1.5360	0.8376	−1.295661†	0.0573
		Panel ADF-Statistic	0.4554	0.3683	0.1285	−0.1233	−0.3046	1.0050
		Group rho-Statistic	3.3447		3.4405		0.9909	
		Group PP-Statistic	1.6631		1.8083		−1.1041	
		Group ADF-Statistic	0.8479		0.7101		−1.1348	

Table 14. *Cont.*

Models		Co-integration Test Null Hypothesis: No Co-integration	Individual Intercept		Individual Intercept and Individual Trend		No Intercept or Trend	
			Statistic	Weighted Statistic	Statistic	Weighted Statistic	Statistic	Weighted Statistic
(5)	GROWTH FDI RULE_LAW	Panel v-Statistic	−1.2978	−1.0993	1.394589†	1.1297	−2.5529	−2.5564
		Panel rho-Statistic	0.7354	0.7656	3.1147	2.8597	−1.794843*	−0.9406
		Panel PP-Statistic	−1.568443†	−1.415265†	2.8852	2.0077	−3.816753***	−3.156792***
		Panel ADF-Statistic	−1.430085†	−1.2416	2.3909	1.3439	−2.534433**	−2.537426**
		Group rho-Statistic	2.0371		4.1321		0.3189	
		Group PP-Statistic	−1.338549†		2.5739		−3.770538***	
		Group ADF-Statistic	−0.9832		1.6086		−2.018076*	
(6)	GROWTH FDI VOICE_ACC	Panel v-Statistic	−2.1255	−1.9365	3.894971***	2.947807**	−2.4596	−2.5230
		Panel rho-Statistic	1.6990	1.6716	3.1083	2.9776	1.0982	1.8708
		Panel PP-Statistic	−0.5114	−0.3768	2.7915	2.3235	0.7232	2.1639
		Panel ADF-Statistic	−0.3276	0.1174	2.4500	2.1509	0.0742	1.9391
		Group rho-Statistic	3.0075		3.9313		1.5779	
		Group PP-Statistic	0.0575		3.0209		−0.5654	
		Group ADF-Statistic	0.9403		2.4051		−2.599532**	

Source: Authors' computations. Notes: Superscripts ***, **, * and † indicate statistical significance at 0.1%, 1%, 5% and 10% respectively. Schwarz Info Criterion was selected for lag length. For the definition of variables, please see Table 4.

Furthermore, to confirm the strength of the outcomes, we apply the Kao test for panel co-integration which is a residuals-based test. Table 15 displays the results of the Kao panel co-integration test. It is obvious that ADF (t-Statistic) is significant, except the sixth model. As such, null hypothesis, specifically there is no co-integration is rejected [109]. Thus, there is a long association between selected measures.

Table 15. The outcome of Kao (Engle Granger-based) panel co-integration test.

	Models					
Null Hypothesis: No Co-Integration	**(1) GROWTH FDI ORR**	**(2) GROWTH FDI GOV_EFF**	**(3) GROWTH FDI POL_STAB**	**(4) GROWTH FDI REG_Q**	**(5) GROWTH FDI RULE_LAW**	**(6) GROWTH FDI VOICE_ACC**
ADF (t-Statistic)	−3.457081***	−3.51358***	−2.678418**	−1.799285*	−2.957034**	−0.688062
Residual Variance	0.010128	0.010301	0.010336	0.009971	0.009585	0.010323
HAC Variance	0.021366	0.022058	0.022258	0.022209	0.016184	0.023863

Source: Authors' computations. Notes: Superscripts ***, **, * and † indicate statistical significance at 0.1%, 1%, 5% and 10% respectively. Schwarz Info Criterion was selected for lag length. For the definition of variables, please see Table 4.

Table 16 reports the results of the Johansen panel co-integration test. For the Johansen panel co-integration test, the suppositions of co-integration tests permit for individual effects, but no individual linear trends in vector autoregression [73]. The null hypothesis of no co-integration is rejected, thus being confirmed the incidence of a long-run association between the variables.

Table 16. The outcome of Fisher (combined Johansen) panel co-integration test.

Models		**Hypothesized No. of CE(s)**	**Fisher Stat. (From Trace Test)**	**Fisher Stat. (From Max-Eigen Test)**
(1)	GROWTH FDI CORR	None At most 1 At most 2	135.8*** 46.99** 37.73*	116.9*** 39.7* 37.73*
(2)	GROWTH FDI GOV_EFF	None At most 1 At most 2	126.7*** 49.74*** 49.92***	106*** 35.41* 49.92***
(3)	GROWTH FDI POL_STAB	None At most 1 At most 2	124.5*** 50.92*** 53.41***	100.8*** 34.92* 53.41***
(4)	GROWTH FDI REG_Q	None At most 1 At most 2	110.9*** 44.86** 50.2***	89.26*** 31.7† 50.2***
(5)	GROWTH FDI RULE_LAW	None At most 1 At most 2	102.9*** 44.29** 44.31**	81.13*** 33.34† 44.31**
(6)	GROWTH FDI VOICE_ACC	None At most 1 At most 2	100.6*** 61.64*** 66.19***	62.01*** 39.13* 66.19***

Source: Authors' computations. Notes: Superscripts ***, **, * and † indicate statistical significance at 0.1%, 1%, 5% and 10% respectively. Probabilities are computed using asymptotic Chi-square distribution. For the definition of variables, please see Table 4.

In as much as the variables are cointegrated, the long-run associations are further estimated via FMOLS and DOLS. The outcomes of the FMOLS and DOLS estimated co-integration connections are displayed in Table 17. The FMOLS outcomes of estimations (1), (3), (4) and (6) provide support for an undesirable influence of FDI on growth, contrary to Pegkas [1], Freckleton, Wright and Craigwell [39]. As well, the DOLS results confirm the negative impact merely in the first estimation. With reference to the institutional quality variables, the outcomes are similar to those reported in Tables 10 and 11, but voice and accountability estimate loses its statistical significance.

Table 17. Panel data examination of long-run output elasticities.

Variables	(1)		(2)		(3)		(4)		(5)		(6)	
	FMOLS	DOLS	FMOLS	DOLS	FMOLS	DOLS	FMOLS	DOLS	FMOLS	DOLS	FMOLS	DOLS
FDI	−0.01* (−2.55)	−0.01** (−2.77)	0.00 (−0.93)	0.00 (−0.69)	−0.01** (−3.28)	−0.01 (−1.63)	−0.01† (−1.92)	−0.01 (−1.21)	0.00 (−1.00)	−0.01 (−0.95)	−0.01** (−3.16)	−0.01 (−1.58)
CORR	0.46* (2.31)	0.35 (1.46)										
GOV_EFF			1.05*** (4.71)	0.91** (3.29)								
POL_STAB					−0.30 (−1.40)	−0.04 (−0.15)						
REG_Q							0.74*** (3.61)	0.70** (2.73)				
RULE_LAW									1.45*** (7.49)	1.29*** (5.99)		
VOICE_ACC											−0.33 (−1.48)	−0.08 (−0.24)
R-squared	0.63	0.73	0.68	0.74	0.63	0.70	0.67	0.73	0.77	0.82	0.64	0.69
Adjusted R-squared	0.60	0.65	0.65	0.67	0.59	0.61	0.64	0.65	0.75	0.77	0.60	0.61
S.E. of regression	0.28	0.26	0.26	0.25	0.28	0.27	0.26	0.26	0.22	0.21	0.27	0.27
Long-run variance	0.15	0.10	0.13	0.09	0.15	0.12	0.14	0.10	0.09	0.06	0.15	0.12
Mean dependent var	9.14	9.14	9.14	9.14	9.14	9.14	9.14	9.14	9.14	9.14	9.14	9.14
S.D. dependent var	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44
Sum squared resid	10.76	7.85	9.39	7.48	10.87	8.81	9.73	7.80	6.69	5.23	10.59	8.87

Source: Authors' computations. Notes: Superscripts ***, **, * and † indicate statistical significance at 0.1%, 1%, 5% and 10% respectively. Panel method: Pooled estimation. Heterogeneous variances. Schwarz lag and lead method in case of DOLS estimation. Figures in brackets show t-statistic. For the definition of variables, please see Table 4.

The outcomes of PVECM Granger causalities are reported in Table 18. Therefore, the following causal relationships are identified for each model:

- Model (1): Short-run one-way causal link running from FDI to growth;
- Model (2): One-way causal link running from FDI to growth, along with short-run unidirectional causal link running from government effectiveness to growth;
- Model (3): Short-run one-way causal link running from FDI to growth;
- Model (4): Short-run one-way causal link running from FDI to growth, alongside one-way unidirectional causal link running from growth to regulatory quality;
- Model (5): Short-run one-way causal link running from FDI to growth and one-way unidirectional causal link running from growth to rule of law;
- Model (6): One-way causal link running from FDI to growth, besides short-run unidirectional causal link running from voice and accountability to FDI.

Table 18. Panel vector error-correction model (PVECM) Granger causalities.

Models	Excluded	Short-Run (or Weak) Granger-Causality			Long-Run Granger-Causality
		Dependent Variables			
		ΔGROWTH	ΔFDI	ΔCORR	ECT
(1)	ΔGROWTH		1.6978	2.3258	−0.124502***
	ΔFDI	12.34713**		0.5063	−10.96881***
	ΔCORR	2.8356	3.0597		−0.001809
		ΔGROWTH	ΔFDI	ΔGOV_EFF	ECT
(2)	ΔGROWTH		1.8875	1.0458	−0.174456***
	ΔFDI	11.45159**		1.1969	−9.440169**
	ΔGOV_EFF	7.444163*	0.4843		0.046016
		ΔGROWTH	ΔFDI	ΔPOL_STAB	ECT
(3)	ΔGROWTH		2.1091	1.4481	−0.140034***
	ΔFDI	8.041205*		2.8072	−8.335268**
	ΔPOL_STAB	0.2664	1.2736		−0.026861
		ΔGROWTH	ΔFDI	ΔREG_Q	ECT
(4)	ΔGROWTH		1.1953	10.78608**	−0.103463***
	ΔFDI	12.49779**		3.7957	−7.632315***
	ΔREG_Q	1.1073	3.1275		0.005832
		ΔGROWTH	ΔFDI	ΔRULE_LAW	ECT
(5)	ΔGROWTH		1.3339	4.764213†	−0.157890***
	ΔFDI	11.30389**		0.8344	−8.213606**
	ΔRULE_LAW	0.5774	1.6971		−0.001021
		ΔGROWTH	ΔFDI	ΔVOICE_ACC	ECT
(6)	ΔGROWTH		1.7856	2.5089	−0.139026***
	ΔFDI	10.69032**		0.9557	−6.247867*
	ΔVOICE_ACC	3.2408	4.73479†		0.012596

Source: Authors' computations. Notes: Superscripts ***, **, * and † indicate statistical significance at 0.1%, 1%, 5% and 10% respectively. ECT reveals the coefficient of the error-correction term. The number of appropriate lags is two according to Schwarz information criterion. For the definition of variables, please see Table 4.

The significance of the ECT is valuable for discussing long-run causality. Therefore, in the long term, we acknowledge a bidirectional causal relationship between FDI and economic growth in all the PVECM models similar to Chan, Hou, Li and Mountain [3], Mahmoodi and Mahmoodi [70], as well as a one-way causal relationship running from each institutional quality indicator to economic growth and FDI.

5. Conclusions and Policy Implications

Foreign direct investment, a crucial factor of globalization, is regarded a noteworthy engine of productivity heightening, technical progress, and job creation. However, reduced institutional quality may discourage FDI inflows. Using panel data for 11 Central and Eastern European countries from 2003 to 2016, current paper examined at first glance the impact of FDI on economic growth, also covering institutional quality measures, as well as several sustainable development goals established in the 2030 Agenda for Sustainable Development [48]. The quantitative outcomes by means of panel data regression models lead us to conclude that a non-linear association occurred between FDI and GDP per capita. In terms of institutional quality, the whole Worldwide Governance Indicators, except political stability and absence of violence/terrorism, exhibited a positive influence on economic growth. Moreover, poverty, income distribution, education, innovation, transport infrastructure and, information technology appeared as significant drivers of growth. The estimations of FMOLS and DOLS confirmed the findings to a partial extent. Furthermore, the panel vector error-correction model Granger causalities provided evidence for a short-run unidirectional causal link running from FDI to growth and a long-run two-way causal connection between FDI and economic growth. Therefore, in the long run, unidirectional causal associations running from each institutional quality indicator to economic growth and FDI were established.

The outcomes may have some policy implications. Therefore, the policymakers out of the CEECs should attempt to attract higher FDI inflows to boost economic growth. Overall, for the development of an appropriate setting to attract FDI, favorable economic, political, social and cultural conditions are more than required [7], alongside macroeconomic steadiness and the decrease of the market deformations [1]. For instance, the labor force in such countries is quite trained, but modern management and worldwide manufacturing knowledge is regularly missing. Therefore, investors with the required capitals, managerial skills, marketing chain, and industry strength are crucial [35]. First, there should be shaped an economic setting that ensure proper rewards to corporations which would bring ideas from overseas and put them to use with inland funds [81]. As such, financial stimulus in form of labor subventions, energy and property rental discounts, allowance on customs duties for main machinery/raw resources, export credit conveniences or tariff shield are required [22]. Secondly, a sound institutional setting should be implemented. The "helping hand" viewpoint may be explained via the early stages of democracy in the explored region. As such, in line with Harms and Ursprung [101], Mengistu and Adhikary [100] and Sabir, Rafique and Abbas [102], the democracy in the CEECs should be deepened in order to spur the inward flow of FDI [18]. Good governance may create suitable environments for investors, respectively lower cost of doing business, lesser uncertainty and upper productivity expectation [32]. A suitable stage of institutional progress can support synergies between FDI and resident companies, thus enhancing productivity spillovers. Also, capital accumulation may be increased by means of complementarities between foreign and internal investment [38]. Moreover, in line with Jude and Levieuge [38], a better institutional quality may entice high-quality technology. Thirdly, the minority shareholders and creditor rights should be enhanced via capital market directives and banking sector reorganizations, aiming to rise equity or bond release. Thus, a better extension of domestic credit to enterprises should be allowed in the benefit of wealth creation [35]. Similarly, strengthening of trade will also help in appealing FDI. Not least, the policies concerning sustainable development goals should be promoted. In this vein, greenfield and brownfield investments may lessen unemployment, while increasing incomes, public and private consumption, capital accumulation and productivity [89]. As well, infrastructure should be improved to guarantee that FDI which is acquired manifest an increased gain to the entire economy. Accordingly, improved transport systems and modern information technology ease the spread of novel products and technologies [47].

This paper has contributed to the prevailing literature by adding evidence for the case of CEECs on the nexus between FDI and economic growth. Future research can be done to explore the drivers of FDI inflows in CEECs.

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The Role of E-Skills in Developing Sustainable Organizations and E-Activities in the New Digitized Business World

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Abstract: Today's business environment is governed by changes and challenges, such as the Internet which is also changing our personal and professional lives, our way of thinking, of acting, as well as our daily activities. By using new technologies and the Internet, any company can do business in any corner of the world, and with the help of e-skills any person can relate with anyone, anywhere, and anytime. Moreover, the world is at our fingertips, opening new opportunities and visions. The purpose of this paper is to analyze the relationship between the e-skills and e-activities. Furthermore, the differences between e-skill and e-activity values recorded for Romania, at the EU28 level, and the values for the best-in-class group are analyzed. Through the use of benchmarking, we show that this gap exists, and thus some improvement measures are proposed. Thus, the correlation among three proposed zones (Romania, the average for EU28, and the best-in-class group) is analyzed with the help of simulation and mathematical modeling. The Excel data analysis shows that the correlation and future trends that could take place at the European level, helps the specialists improve skills, overcome risks, make better decisions, reduce costs, and increase performance.

Keywords: sustainable development; sustainable organizations; globalization; e-skills; e-activities; EU28; simulation and modeling

1. Introduction

E-skills are very importance in this new age, for job applications, communications, online booking, banking, and ordering, as well as completing online courses. Today, businesses face many challenges such as sustainability, globalization, and the development of new technologies. The electronic evolution has affected all organizations and its influences continue to grow. Internet use has had an impact on all business process, including communication [1] (p 94). Globalization has changed the way people and communities relate [2] (p1). The Internet has the ability to change and influence many activities and fields and enables people to live and work wherever they desire [3] (p 3), becoming sustainable and obtaining sustainable performance. Employees who are involved in sustainable activities and adopt sustainable development principles, become sustainable human resources [4]. Today, the challenge is not related to how to implement new technologies but how to acquire new e-skills, use them properly and sustainably, and combine them with other channels of communication. On the basis of these reasons, the scope of this research is to use simulation and mathematical modeling to show that there is a positive and very strong relationship between sustainable HR development and Internet use, which leads to an increase in the e-skills and e-activities mentioned above. The correlation function and

Excel data analysis were used for the analysis and comparison among the three established zones (Romania, average level at the EU28 level, and the best-in-class group), and demonstrated that there is a relationship which shows the future trends on the European level, therefore, helping specialists increase skills, overcome risks, make better decisions, reduce costs, and increase performance. Some research hypotheses were established such as there is a correlation and a strong and positive relationship between e-skills and some e-activities developed in the new digitized world.

Many studies have been carried that studied the sustainable development of a performance organization [5,6] (p 202 and p 89) and the role of training e-competencies for competence jobs, for competence programs, to improve HR training and development, or to map processes [7] (p.120), [8] (p.1459), [9–11], [12] (p.1), however, these studies did not analyze the relationship between the e-skills and e-activities in order to obtain sustainable performance. Thus, the novelty of this study is important to others as well as the specialists in the field. The study is organized as follows: Section 2 presents a literature review and an explanation of the existing factors that influence sustainable development including the trend of Internet use, as well as the importance and evolution of e-skills, digitization, and e-activities; in Section 3, the research methodology is presented, in Section 4 the framework for the analysis of the relationship between the variables through the prism of the correlation between the three zones and Excel data analysis, and the results obtained by implementing the correlation matrix on the level of the three zones; and in Section 5 the discussion and conclusions are presented.

2. Literature Review

In this section, a literature review of the studies on the relationship between e-skills and e-activities is presented. For its measurement, some tools and tests were used, such as correlation matrix, benchmarking analysis, and Excel data analysis. Due to globalization and new technologies, all processes, including communication, are changing and organizations are using flexible networks to communicate [13] (p 1). The world is becoming smaller and inter-related using the Internet to create trust and facilitate working in teams [14] (p 257), as well as making information available to anybody at any moment [15] (p 171). In terms of technology, we live in a golden age of communication. Global communication has been helped by the Internet, e-mails, faxes, mobile phones, and text messaging, as well as the mediated communication through Internet, e-mail, and mobile phones [16] (p 67). According to the official statistics, the number of Internet users increased from 360 million in 2000 to 4.5 billion in 2019 [17], and the number of websites increased from 17 million in 2000 to 1.5 billion in 2019 [18].

This exponential development has mainly been due to the constraints created by globalization. No one, nor physical persons or juridical ones, cannot allow for a ”technological fracture”, because this will mean the exclusion from the regional (European) market which actually became a global one [19] (p 30). In the past few years, there has been a growth in Internet markets [20] (p 15). According to the principle, healthy people in healthy organizations, producing healthy products for healthy customers, human resource plays an important role in the application of the sustainable development activities by developing its e-skills.

Efficiency in organizations is achieved by their human resources, their behavior, knowledge, and skills, as well as sustainable development. Sustainability of an organization is achieved by the skills of the employees, leadership, and managers in deploying activities. In a world where the resources are limited, accepting sustainability supposes the responsibility towards future generations. The learning of the continuous development of the human capital must also become sustainable, allowing organizations to compete in a changing market which is economically and socially responsible. First, sustainable processes must be aligned with the business model, used by all departments, and understood by all employees.

The Internet has become the universal source of information for millions of people, at home, at school, and at work [21]. In 2005, on average 27.3%, and in 2019, 49.7% of the households in the EU had a personal computer at home; whereas, in 2004, 42%, and in 2018, 89% had a home Internet connection.

The penetration of computers and especially of the Internet remains lower in thinly populated, rural areas throughout the European Union [22].

Communication has contributed to the global connection of society through the Internet. Men and women, and especially the new generation, are online almost all of the time [23] (p.1). Internet, especially e-communication, provides the opportunity to exchange ideas and information at the global level [24] (p 43). The Internet will become the most convenient tool of global communication worldwide [25] (p 10), enabling even small businesses cross many internal barriers [26] (p 20) and enter to the global market. Due to exceptional online experience [27] (p.2), from 2002, Internet traffic has increased by 86 percent a year, and from 1995, websites have increased from 20,000 sites to over 36 million by 2002 [14] (p 68), and by 2020, to 1.7 billion websites [18].

The Internet is not just about connecting people, it is about attracting customers, offering them independent choise, diversity, transparency [28] (p.45), convenience or flexibility [29], and maintaining and growing relationships with stakeholders. In North America, 88.1% (2018) and 89.4% (2019) use the Internet, while 77.4% (2018) and 87.7% (2019) from the European population and 47.7% (2018) and 58.8% (2019) worldwide use the Internet [30], and employees use e-mails every day (with 269 billion e-mails sent every day in 2017 and 306 billion e-mails sent in 2019 [31], however, e-communication is not yet a substitute for face-to-face communication, but a new means to communicate faster and cost effectively.

The Internet reduces face-to-face meetings with clients, creating psychological barriers and physical distance; but modeling, used in many fields, and in our case in e-activities, will bring benefits for companies and for customers, being a paramount to economic policy [32]. In addition to this type of communication, managers use e-mails, intranet, videoconferencing, or enterprises' software to communicate with their employees [33] (p 165). IBM, for example, offers more than 5000 audio and video podcast "episodes" for employees to watch or listen whenever they have time.

2.1. Digitization: The Challenge for a New Business into a Sustainable Environment

In the new digitized era, full of change and challenges, the speed, cost, and novelty of transmitting data is important for any company. The Internet helps organizations transmit data rapidly using computers and the e-skills of employees. Thus, e-communication satisfies the need for efficient transmission of information and knowledge into a globalized and digitalized world. Without these new skills, organizations are not able to gain a competitive advantage, performance, or satisfy new customers' needs in a sustainable way, i.e., fast, cheap, and well.

According to this vision of digitization, we present important and challenging processes such as the ones presented in this work.

Using digitization at work, employees should acquire knowledge and experience as in [34] (p 150) as follows:

- Representing the stages of any process;
- Exchanging information between various people and stages;
- Understanding the flow of information and the consumption of resources (time, financial, and human);
- Being compatible with the applications used.

Any application used must meet the following four criteria: be fast and easy to use, allow comparison between the new and old models, provide a process model that is not only descriptive but also analytical, and allow the conduct of subsequent changes in the process design. Digitization can offer an organization a competitive advantage in the market, however, every competitor has access to the same technologies, and therefore can offer the same product and service, thus, the main aspect in winning customers' trust and be chosen by these is to create flexibility for its systems, to develop its people's skills (e-communication and e-collaboration), and to develop its infrastructure which can provide a bridge for interconnectivity.

The infrastructure of any organization offers [34] (p 151) the following:

- New work conditions (send e-mails, acquire new PCs, develop new portals, process data, make decisions, and create strategies);
- New ways to decrease the costs (due to standardization, timely information on the new demands of customers or suppliers);
- New ways to communicate faster (provide tracks, make provisions, knowledge of the consumption of resources, offer understanding and to differentiate from the competition);
- New ways for stakeholders to have benefits (improve the market' position, satisfy customers, employees, and managers' needs).

2.2. E-Skills: Importance for Sustainability and Trends

In order to obtain a performance and a competitive advantage, sustainable organizations must attract, acquire, motivate, and maintain the skilled and talented people who bring performance into the organizations. Better skilled employees mean better performance. Knowledge is a strategic resource and it is sustainable because it is not easy to imitate or copy [35] (p 161). Thus, these employees must possess skills, competencies, experience, and knowledge bringing improved products and results for their organizations, employees, and customers. The following are among the most wanted skills: essential and occupational skills, cross-disciplinary skills, cognitive skills, problem solving skills, communication skills, foreign languages, and computer skills. Information and communication technology (ICT) skills or e-skills enable an employee to actively participate in a challenging new Knowledge-economy, by using new technologies and e-communication techniques (e-mail, e-conferences, Internet, intranet, databases, and websites).

There are four types of e-skills [36] (p 47) as follows:

- ICT practitioner skills, i.e., the capabilities required for researching, developing, designing, managing, producing, consulting, marketing, selling, integrating, installing, administrating, maintaining, supporting and servicing ICT systems;
- ICT user skills, i.e., the capabilities required for the effective application of ICT systems and devices by the individual;
- E-Business skills, i.e., the capabilities needed to exploit opportunities provided by ICT to explore possibilities for new ways of conducting business and organizational processes, and to establish new business;
- E-Literacy, i.e., the capabilities needed for socially appropriate ICT for local development.

Hiring requires criteria beyond any real change in the skills necessary to perform productively [37] (p 116). E-skills usually refer to a broad set of skills necessary in the modern workplace [38] (p 807). The Commission of the European Communities (2007) extended this definition stating that e-skills represent a set of skills, knowledge, and concepts that are needed for effective consumption in terms of accessing, locating, operating, managing, understanding, and evaluating e-services provided in different stages of e-government. There are five levels of e-skills [39] as follows:

1. A basic level of e-skills is close to ICT user skills and employees who possess these e-skills can use generic tools such as Word, Excel, Outlook, and PowerPoint for basic tasks.
2. A middle level of e-skills is represented by employees who are practitioners that have the ability to research, develop, design, plan, manage, produce, integrate, support, and service ICT systems.
3. An ICT specialist includes employees who have the ability to use advanced IT tools to develop, operate, repair, maintain, and create ICT systems.
4. The E-leadership skills level includes employees who have the ability to exploit opportunities provided by ICT and are expected to ensure effective performance.
5. ICT professionalism skills represent the highest level of e-skills. These employees have comprehensive and up-to-date knowledge, accommodating a common ICT body of knowledge and

skills. They possess a combination of qualifications, certifications, work experience, non-formal and informal learning, as well as can offer high-quality products and services.

Achieving e-skills is not an isolated process but it is tightly linked to the highest national development policies or internationally accepted obligations. E-skills offer some benefits: sharing knowledge, collaborating, using software and learning from others, having fun, being creative, making friends, as well as practical and generally positive skills. In 2003, the European e-Skills Forum was established by the European Commission to promote the effective use of ICT and its successful introduction in all major areas of human activity, especially in the business and industrial sectors.

The need for ICT-related skills (e-skills) has been recognized in 2002 at the European e-Skills Summit. At the 2004 Forum, e-skills were divided into the following three categories: ICT practitioner skills, ICT user skills and e-business skills, which offer the opportunity to exploit the Internet and to ensure effective performance [40] (p 66).

Statistical research on the population has been carried out based on the specific activities related to computer and Internet usage.

The following information is provided to better analyze and compare the evolution of e-skills:

1. The e-skills of the population [40] (p 53):
    - about 50% of the population have basic skills;
    - 50% know how to copy and paste tools (in Iceland and Denmark about 65% of the population knows how to do this; and for Latvia, Poland, and Lithuania 30% to 33% know these skills);
    - 4 in 10 know how to send e-mails with attachments (in Iceland the share is 68%);
    - the average level of the way of training e-skills is 28% for EU27; countries such Iceland (51%), Sweden (40%), UK (38%), Estonia and Cyprus (36%), Luxemburg (35%), Latvia (34%), Lithuania (33%), Belgium, Denmark, and France (32%), and Hungary (31%) are over this average, but countries such as Bulgaria and Spain (20%), Romania (17%), and Italy (16%) are under this average [41].
2. The individuals' level of computer skills [22]:
    - Countries such as Luxemburg (83%), Norway (82%), Iceland (80%), Denmark (75%), Germany (74%), and France (73%) have the level of computer skills over the average of the EU27, and Romania (27%) is far from this average (64%).
3. The individuals' level of Internet skills:
    - Countries such as Iceland (93%), Denmark and Netherlands (92%), and Luxemburg and Norway (91%) have the level of Internet skills much above the average of the EU27, but Romania (50%) is again below the average of the EU27 (75%).
4. The individuals' frequency of Internet use:
    - Countries such as Norway (98%), Iceland (97%), Netherlands and Luxemburg (96%), Denmark and Estonia (95%), and Belgium and Hungary (90%) are above the average of the EU27 (87%), but again Romania is much below this average (61%).
5. The employees' level of Internet access in 2014:
    - The average of the EU27 was 99%, and the majority of countries had over 97% (Denmark, France, Lithuania, Luxemburg, Netherlands and Finland had 100%, and Germany, Czech Republic, Ireland, Spain, Italy, Cyprus, Latvia and Portugal had 99%, Hungary and Malta have 97%, only Romania has 92%.
6. The enterprises' level of Internet access:

- In 2008, the EU27 average was 93%; countries such as Finland (100%), Slovenia and Netherlands (99%), Austria (98%), and Estonia (97%) were above the EU average, but Romania had 67%, which was much below this average [22].

2.3. The Evolution of E-Activities in the Globalized World

Due to the continuous changing work environment, market liberalization and internationalization, as well as globalization which bring technology in foreground [42] (p.51), organizations use more and more e-communication and employees' e-skills in order to satisfy stakeholders' needs. Human capital is a central pillar of growth and productivity, thus, investing in people and skills is a vital topic for policy makers and enterprises, and therefore the share of the labor force with ICT skills has been steadily growing. Adapting education and training systems for a knowledge society is a crucial issue as a means to reduce the digital divide. The diffusion and use of ICT modify employment, work, and skill patterns. ICT usage fosters lifelong learning and enables workforce mobility. Any field effectiveness depends mainly on the skills of employees facing a challenging environment. Modernization has imposed the use of new information and communication technologies (ICT) and these have led to new demands regarding the skills of employees, especially in activities such as e-banking, e-booking, e-communication (using e-mailing), e-recruitment, e-government, e-commerce, e-development, and e-information.

2.3.1. E-Banking

E-banking is defined as web-based banking which involves individual and corporate clients and includes many online services for them [43] (p 2). One characteristic of e-banking is the sheer speed of new technological developments along with a high pace of competition and changing customer preferences. In order to be the first on the market, a bank must anticipate trends to be able to respond to competitors and gain a competitive advantage [44] (p 237).

The data on online banking penetration in European countries shows that, in 2018, 89% of the Danish population, the Netherlands, and Finland were the strongest European countries with the greatest online banking penetration in the EU28, with Romania and Bulgaria being the last ones with 7% who had accessed online banking sites.

2.3.2. E-Commerce

E-commerce refers to the use of electronic means and technologies, such as the sale, purchase, transfer, or exchange of products and services or information [45]. E-commerce means making business transactions using the Internet [46] (p 506) and is more than just retail, i.e., it is about production, advertising, sale, and distribution using telecommunication networks [47] (p 2). This process connects consumers who are online and mobile, and communities on the electronic platforms, which have become an integral part of their life [48] (p 731). The Internet offers opportunities and a great potential for small enterprises, but also for developing countries [49].

In 2018, in the EU28, the percentage of enterprises making e-sales ranged from 11% (Bulgaria and Greece) to 30% to 39% (Ireland, Denmark, Sweden, Belgium, and Czechia) [50]. During 2018, 43% of large enterprises conducted e-sales, having an e-sales value of 25% of the total turnover in this size class; 28% of medium sized enterprises made e-sales generating 14% of the total turnover in this size class; and 18% of small enterprises were generating 8% of the turnover of such enterprises [42]. During 2018, 14% of EU enterprises conducted e-sales using only websites or apps, 3% used only EDI-type sales, while another 3% used both [51]. Web sales were the dominant mode of conducting e-sales in all the EU28, in 2018. The percentage of enterprises receiving electronic orders only over websites or apps ranged from 22% in Ireland to 9% in Greece and Romania [52]. The percentage of enterprises that had e-sales increased by seven percentage points, from 13%, in 2008, to 20% in 2018, and the turnover for the same period from 12% to 18% [53].

2.3.3. E-Recruitment

The Internet has changed the way of searching for a vacancy [54] (p 114). Doran A. said in 2001 that almost all recruiting is done on the web. The online job market increased faster than the traditional recruitment market, growing from 82% in 2004 [46], to approximately 100% in 2006 [55] (p 63). Today, almost all activities are completed online. With the use of online recruitment ads, the recruitment costs have been reduced by 85% [56], thus, becoming sustainable. Until 2005, according to a survey, large organizations used e-recruiting systems between 70% and 90%, and it is anticipated that over 95% of organizations plan to use them in the near future [57]. E-recruitment offers many advantages such as rapid access, winning time, lower costs, 24/7/365, broad range of applicants, and worldwide accessibility [4].

As we observed at the EU28 level, in 2017, the percentage of individuals using the Internet to look for a job or send a job application was 17%, and in 2018, it was 18%; Finland (29%), Sweden (27%), Netherlands (25%), Denmark (24%) were sited as being in the top positions, and Romania (8%), Bulgaria (7%), and Czechia (5%) were in the lowest positions [22].

2.3.4. E-Communication by Using E-Information and E-Mailing

With Internet development, a new way of communicating entered the new cybernetic space, i.e., communication through e-mail which supposes information exchange and depends on the one using it, the program used, the moment of transmitting and receiving, and the answers given [24].

Some people use other languages and grammar suffers [23] (p 1) in order to reduce the time for writing, calling it the phenomenon of ”ne-etiquette” [58] (p 15). According to international statistics, in January 2017, the number of e-mails sent daily was 269 billion and, in 2019, there were 306.4 billion; the number of e-mail users worldwide in the same year was 2.67 billion, and in 2018 it was 3.8 billion [51]. E-mail has had an important influence on the workplace since the late 1990s. Some of the effects of this type of communication were positive at work, and others reduced the benefits of face-to-face communication. At the EU28 level, we observed that 71% of individuals between 16 and 74 years old used the Internet to send and receive e-mails; and in countries such as Denmark (93%), Louxemburg (93%), Norway (92%), Netherlands (90%), Sweden (88%), and Romania was in the final place with 42% [51]. As a result of using e-mail communication, the paper consumption was lower, thus, making organizations more responsible.

2.3.5. E-Development

E-development is clearly a product of more general development. E-development solutions can be costly, with a high failure rate but with important results, i.e., achieving better productivity, efficiency, and quality of life; staying attractive, competitive, and innovative [59]; having better relationships with customers; and having better trade and delivery of services. E-development uses the Internet or Intranet [60] to receive guidance and new knowledge; to improve sharing and a two-way development as a win-win situation; or to use simulation in order to improve future performance [61] (p 229). Better results for employees and organizations with better development and training has made organizations sustainable.

The data recorded at the EU28, in 2019, show that individuals use the Internet to do an online course (considered the e-development activities) as follows:

- The average of using e-development activities is at EU28 with a level of 10;
- Finland level 21, UK level 19, Spain level 15, Estonia level 14, Netherlands level 13, Denmark level 12, are the leaders in using training and education via the Internet;
- The lowest rate of individuals using the Internet for this purpose is found in Croatia having a level 5, Latvia level 4, Romania level 3, and Bulgaria had a level 2 [62].

3. Research Methodology

Many factors influence the e-activities, such as the degree of ICT adoption or the nature of the used networks [63] as the skills necessary for sustainable human capital, proven by the fact that many processes were influenced by the use of the Internet. However, none of the studied articles analyzed the relationships between the described e-skills and e-activities, especially between countries, by years or against the best-in-class. The data on these processes were extracted from the European level (from the official site of Eurostat.com for Science, technology and digital society Internet use) presented between 2015 and 2019. The main objective was to show the relationship between e-skills and e-activities based on the principle that by having e-skills, the employees from the new e-work age will achieve sustainable performance in e-activities, such as e-recruitment, e-development, e-communication, e-banking, and e-commerce. Moreover, due to the fact that these e-activities are influenced by the detained level of e-skills, the correlation function was chosen, in order to measure the impact of e-skills on the analyzed e-activities. The analysis started from the comparison by years between Romania and the average of the EU28 countries and the best-in-class group (formed by the four European countries which repeatedly got the highest values on e-activities on years). With the use of benchmarking, the difference between Romania and the EU28 level was determined, as well as the best-in-class, making reference to e-skills and e-activities. Thus, among the best-in-class, the following countries were selected: Denmark, Finland, Netherlands, and Sweden.

Some research hypotheses were established as follows:

Hypothesis 1 (H1). *There are differences between the described variables, compared by countries and by years.*

Hypothesis 2 (H2). *There is a correlation between e-skills and the considered e-activities.*

There is an increase in using modeling [64] (p 399), forecasting and simulation [65] (p.139), which are important for any organizations, no matter the size or the field, and it is based on using past data, in order to see a possible future which will help to observe the risks or the factors which influence the analyzed variables.

In our research, the data from the EU28 level are used and the variables are the following: y, individuals level of digital skills (e-skills); X1, individuals sending and receiving e-mails (e-mailing); X2, individuals using the Internet to find information about goods and services (e-commerce); X3, individuals using the Internet for internet banking (e-banking); X4, individuals using the Internet to look for a job app (e-recruitment); X5, individuals using the Internet to do an online course (e-development).

In order to achieve the objective and to test the research hypotheses, trend analysis for the analyzed three zones, and correlation matrix in combination with Excel data analysis are used.

4. Results

4.1. Analyzing the E-Skills and E-Activities at the Established Three Zones

Each variable is analyzed and the trend is viewed for Romania, the EU28 level, and the best-in-class group in order to observe the differences.

4.1.1. Analyzing the E-skills Trend

The data regarding e-skills are presented by years and for the three chosen zones (Table 1).

Table 1. Data about e-skills (y) [66].

Years	EU28	RO	The Best-in-Class			
			Den	Fin	Neth	Swe
2015	55	26	75	74	72	72
2016	56	28	78	73	77	69
2017	57	29	71	76	79	77
2018	57	30	71	76	79	75
2019	58	31	70	76	79	72

According to the European Commission Report, Romania shows limited e-skills policy activity. The NRI ranking (networked readiness index) reveals again that those countries with high NRI positions also show high e-skills policy activity levels (Figure 1). The NRI rank for the EU27 shows that Romania is at the 25th rank for the 27 European countries [67].

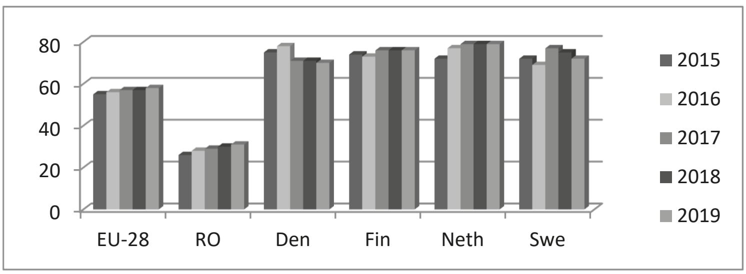

Figure 1. Graphic representation of e-skills by countries and by years.

The values for e-skills (Figure 1) are above average for the EU28 countries (58 in 2019), with Romania being much below the average (31 in 2019), although it is following a positive and increasing trend. For the best-in-class group (DFNS) an increased trend is observed (values between 70 and 79 for 2019), thus, H1 is fulfilled, i.e., there a difference between the e-skills values observed at the level of the three analyzed groups. Romania, due to the reduced number of computers (11/100 capita in 2004, 19/100 capita in 2007, and 47/100 in 2015) as compared with the Netherlands (91/100 in 2007 and 97.6/100 in 2017), Sweden (88/100 in 2007 and 92.8/100 in 2017), Denmark (55/100 in 2007 and 93.1/100 in 2017), and Finland (50/100 capita in 2007 and 93.5/100 in 2017) [68–70] has a reduced level of e-skills, however, there are other issues such as many villages have no energy power, the increased age of the population, the increased number of children who are not at school, and other indicators.

4.1.2. Analyzing the E-Communication by Using E-Mailing

E-mail continues to be an important part of personal and professional life. It continues to grow daily as part of the Internet experience and use. The total number of business and consumer e-mails sent and received per day was 293.6 billion in 2019 [71]. Data on sent and received e-mails are presented for the three analyzed zones between 2015 and 2019 (Table 2).

Table 2. Data on the number of sent and received e-mails (e-communication) (x1) [72].

Years	EU28	RO	The Best-in-Class			
			Den	Fin	Neth	Swe
2015	69	43	79	86	90	83
2016	71	42	93	85	91	88
2017	72	45	94	89	93	91
2018	73	42	94	89	92	86
2019	75	43	94	90	93	91

In January 2017, the number of daily sent e-mails was 269 billion and 293.6 billion in 2019 [73] (Figure 2).

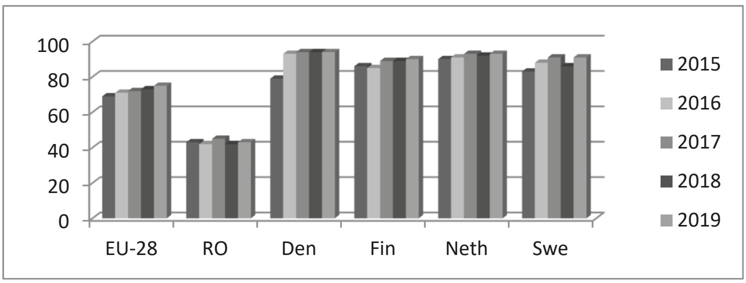

Figure 2. Graphic representation of e-mailings by countries and by years.

We observe that the number of sent e-mails is continuously increasing, however, according to the table, the data from Romania show that, in 2019, the individuals using the Internet to send and receive e-mails (43) is much below the average for the EU28 countries (75), and much more below for the analyzed group (90–94), again H1 is fulfilled, i.e., there is a difference between the analyzed values present on the level of the group for e-mailing.

4.1.3. Analyzing the E-Commerce

According to a study, in 2018, Northern Europe has the highest spending per online shopper [74]. Although the European B2C e-commerce turnover was 621 billion euros in 2019, the shoppers from Romania continue to shop traditionally rather than online. Data on e-commerce are presented below for the three analyzed zones (Table 3).

Table 3. Data on information about goods and services (e-commerce) (x2) [75].

Years	EU28	RO	The Best-in-Class			
			Den	Fin	Neth	Swe
2015	61	26	77	82	84	73
2016	66	35	86	85	85	83
2017	65	31	79	85	88	84
2018	70	41	86	84	89	83
2019	68	33	85	87	89	83

According to a study (GpeC), the online shopper in Romania is between 25 and 35 years old; about eight in ten shoppers live in cities; and 90% of online shoppers prefer to pay-on-delivery (Figure 3).

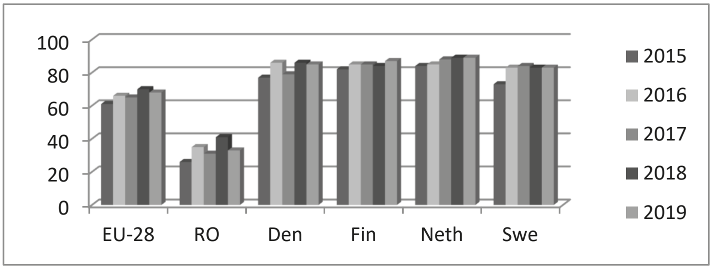

Figure 3. Graphic representation of e-commerce by countries and by years.

Even if Romania is one of the biggest e-commerce industries from southeastern Europe, the share of e-commerce in total retail is still quite low, between 2.2% and 2.5% [76]. Romania (33%) is far from the EU28 (68%) and the best-in-class group (83% to 89%), indicating that H1 is again fulfilled, and that there is a significant difference between e-commerce variables.

4.1.4. Analyzing the E-Banking

About 51% (2017) and 58% (in 2019) from European adults use e-banking which is popular among people between 25 and 34 years (among those with higher education, 77% use e-banking and among those with no higher education only 24% use e-banking [77]). Data on e-banking are presented below by years and for the three analyzed zones (Table 4).

Table 4. Data on using the Internet for online banking (e-banking) (x3) [78].

Years	EU28	RO	The Best-in-Class			
			Den	Fin	Neth	Swe
2015	46	5	85	86	85	80
2016	49	5	88	86	85	83
2017	51	7	90	87	89	86
2018	54	7	89	89	89	84
2019	58	8	91	91	91	84

The four countries from the analyzed group use e-banking between 84% and 91% of individuals between 16 to 74 years, in 2019, and Romania is in penultimate place with 8%. Its trend is increasing, but it is still low as compared with the average and the analyzed group, thus, indicating again that H1 is fulfilled, showing a significant gap from 8% (the value recorded in Romania) to 91% (the highest value from the analyzed group) (Figure 4).

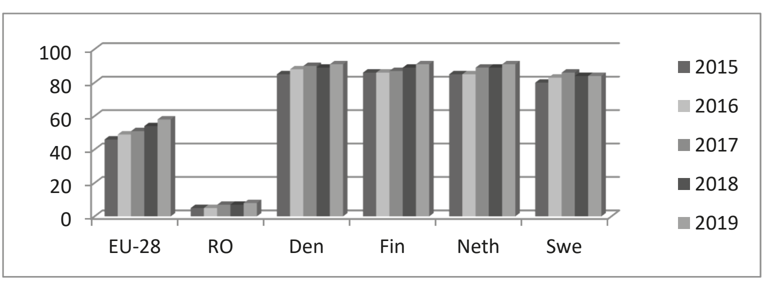

Figure 4. Graphic representation of e-banking trend by countries and by years.

E-banking in Romania has been increasing slowly (8% in 2019) as compared with the average of the EU28 level (58% in 2019) or the analyzed group (between 84% and 91%). We observed that the trend of e-banking in Romania has been increasing from 2007 (2%) to 2012 (3%) to 2018 (7%) and 2019 (8%).

4.1.5. Analyzing the E-Recruitment

Attracting the best candidates is a strategic task. E-recruitment has become the ultimate tool for attracting and retaining valuable candidates and it helps increase their trust in the organization's brand. Today, the e-recruitment is about using new social media, i.e., Facebook, LinkedIn, and other new e-recruitment solutions. The global e-recruitment industry recorded an annual growth of 7% in 2016 [79]. Data on e-recruitment is presented below (Table 5).

Table 5. Data on using the Internet to look for a job application (e-recruitment) (x4) [80].

Years	EU28	RO	The Best-in-Class			
			Den	Fin	Neth	Swe
2015	17	6	36	27	24	26
2016	17	7	30	28	25	27
2017	17	8	24	29	25	27
2018	17	6	30	31	25	29
2019	17	5	37	32	25	30

Studies show that recruitment is carried out almost totally by using the Internet, but only some countries have increased values (Figure 5).

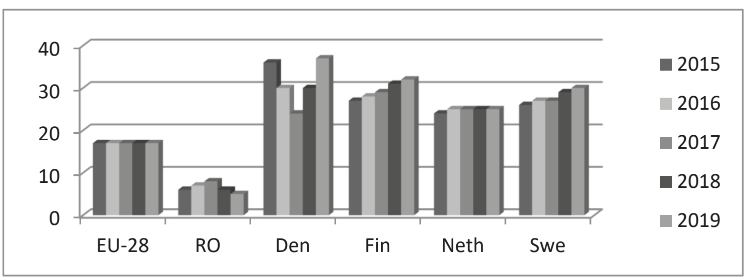

Figure 5. Graphic representation of e-recruitment by countries and by years.

In Romania, we observe that there are still lower percent (6 in 2015, 8 in 2017, and 5 in 2019) as compared with the average values for the EU28 (17 in 2015 and 17 in 2019), and for the analyzed group (values from 25 to 37 in 2019), indicating an important gap (5) as compared with the greatest value from the group (37), and also that H1 is again fulfilled.

4.1.6. Analyzing the E-Development

According to the data presented in the official EU statistics, Romania has values between 3 and 4 (from 2015 to 2019) as compared with the average of the EU28 (6 to 10 between 2015 and 2019) and the analyzed group between 12 and 21 (from 2015 to 2019) for e-development. The data on e-development was collected and divided by years, as shown in Table 6.

The graphic representation of e-development data is presented below (Figure 6).

Table 6. Data on using the Internet to do an online course (e-development) (x5) [81].

Years	EU28	RO	The Best-in-Class			
			Den	Fin	Neth	Swe
2015	6	4	7	13	8	7
2016	6	3	8	14	9	8
2017	6	3	9	16	10	18
2018	7	3	11	18	12	18
2019	10	3	12	21	13	18

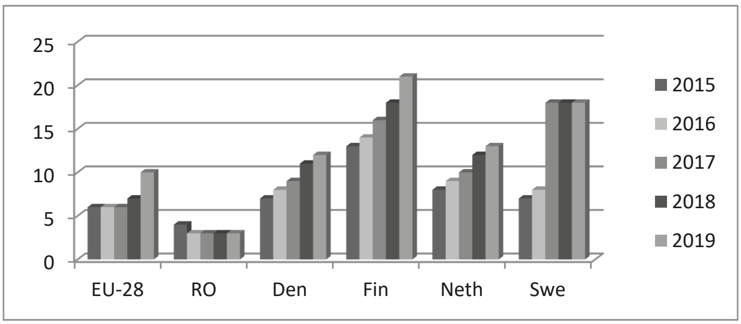

Figure 6. Graphic representation of e-development by countries and by years.

Romania (3) is much below the registered average value and the best-in-class group (21 the highest value), H1 being fulfilled, and showing a gap for the e-development variable between the analyzed countries. The global e-learning market was worth \$107 billion in 2015 and is predicted to reach a total market value of \$325 billion [82].

4.2. Analyzing the Correlations Between E-Skills and E-Activities on the Three Analyzed Zones

4.2.1. Zone 1 EU28 Level

The correlation between e-skills (y) and e-activities (x1 to x5) wa determined by analyzing all the data (between 2015 and 2019) for all the analyzed variables (y and x1 to x5), for the three analyzed zones (EU28, Romania, and the best-in-class analyzed group). As a result of calculating the correlation from 2015 to 2019 between the e-skills and the e-activities at the EU28 level the following results (Table 7) are obtained.

Table 7. The correlation between the analyzed variables at the EU28 level.

For EU28	Y
x1	0.980581
x2	0.775891
x3	0.959688
x4	-
x5	0.759555

Calculations made by the author using Excel data analysis.

Thus, the correlation between e-skills and:

- E-mailing (0.98) is very high, being between +/- [0.9–1),
- E-commerce (0.77) is high, being between +/- [0.7–0.9),
- E-banking (0.95) is very high, being between +/- [0.9–1),

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- E-recruitment (it is not existing due to its constant registered values),
- E-development (0.759) is high, being between +/- [0.7–0.9).

We observe that at the EU28 level, there are positive and strong correlations among the analyzed variables, being between 0.76 and 0.98.

4.2.2. Zone 2 Romania

For the Romanian level the following calculations are obtained.

As a result of calculating the correlation from 2015 to 2019 between the e-skills and the e-activities presented on Eurostat.com, for Romania's level the obtained results are presented in Table 8.

Table 8. The correlation between the analyzed variables for the Romanian level.

For RO	Y
x1	0
x2	0.643
x3	0.910
x4	−0.296
x5	−0.813

Calculations made using Excel data analysis.

Thus, the correlation between e-skills and:

- E-mailing (0) is nonexistent, being 0. Comparing the values obtained officially in the EU28, the value for Romania is 43 in 2019, the average for the EU28 level is 75, and for Denmark it is 94 in the same year.
- E-commerce (0.643) is moderate, being between +/- (0.5 and 0.7). This value shows a real image, because the official statistics indicate that Romania has an indicator of 33 in 2019, the average for the EU28 is 68, and the highest indicator for the analyzed group is for Netherlands with 89 in 2019.
- E-banking (0.910) is very high, being between +/- (0.9–1).
- E-recruitment (−0.296) is negative and very weak, being between +/- (0 and 0.3). Studies showed that e-recruitment in the world is almost 100%, but, as we observed, Romania does not follow the pattern, in 2019, having an indicator of 5 as compared with Denmark (37), so e-recruitment must be perceived by specialists in the HR field as being a future process which can offer real advantages, such as reduced costs, anytime, anywhere for anyone who has a computer, internet and e-skills.
- E-development (−0.813) is negative and high, being between +/- (0.7 and 0.9). The studies show that in Romania (3), in 2019, the level of e-development is reduced as compared with the average of the EU28 level (10) and Finland (21) in the same year.

Thus, we observed, for the Romanian level that there are positive, as well as negative values or nonexistent, showing weak, moderate, or strong correlations between e-skills and e-activities. According to the calculation, the least used e-activities in Romania are e-recruitment (having a weak correlation with e-skills), and e-development (−0.83).

4.2.3. Zone 3: The Best-in-Class Analyzed Group

At the best-in-class group level the calculations obtained are shown in Table 9.

Table 9. The correlation between analyzed variables at the best-in-class group level.

For Den	Y	For Fin	Y	For Neth	y	For Swe	y
x1	−0.9032	x1	0.978492	x1	0.897656	x1	0.237129
x2	−0.01723	x2	0.389249	x2	0.878627	x2	0.246626
x3	−0.67247	x3	0.733869	x3	0.77407	x3	0.592349
x4	0.041946	x4	0.767244	x4	0.958373	x4	0.098725
x5	−0.78213	x5	0.771142	x5	0.779055	x5	0.717925

Calculations made using Excel data analysis.

Thus, the correlation between e-skills and:

- E-mailing for Denmark (−0.90) is negative and reduced, for Finland (0.97) is very high, for Netherlands (0.89) is high, and for Sweden (0.23) is positive but very weak.
- E-commerce for Denmark (−0.01) is negative and very weak, for Finland (0.38) is reduced, for Netherlands (0.87) is very high, and for Sweden (0.24) is positive but very weak.
- E-banking is negative only for Denmark and for the others is moderate and high.
- E-recruitment is positive but weak only for Denmark (0.04) and high and very high for the others from the analyzed group.
- E-development is negative but high for Denmark, and for others high.

It is observed that at the level group the most correlations are high and very high, the only exception being Denmark, even if their indicators are high enough as compared with other European countries or the European average. A comparative analysis was carried out in order to observe the evolution of e-skills and e-activities at the Romanian level.

This comparison was first made with the average existing at the EU28 level and then, making a benchmarking analysis.

Thus, the following five steps, specific for the wheel of benchmarking, were followed [83] p 34:

1. Plan the process which must be analyzed. In our case, we chose to analyze the e-skills and e-activities by observing and analyzing the trends and gaps, and the impact e-skills on e-activities could have using correlation matrix and Excel data analysis.
2. Search for partners necessary for the analysis. In our case, Romania is the benchmarker, and the EU28 level and the best-in-class group are the benchmarkees.
3. Observe their best practices. Each e-activity is presented between 2015 and 2019, and a comparison is made in order to adopt the best practices and regulations in the field.
4. Determine the differences of performance and the gap existing for each activity. According to the data analyzed above, there are significant differences recorded at the Romanian level as compared with the average value at the EU28 level and at the best-in-class level (the gap being even much wider, especially for the following e-activities: the largest gap is in e-banking (from 8 to 58 (EU28) and from 84 to 91 in the analyzed group), in e-recruitment (from 5 to 17 and from 25 to 37), and in e-development (from 3 to 10 and from 12 to 21),
5. Adapt to the best practices. Many studies have demonstrated that a higher performance is the result of new technologies used in micro- and macroenvironments. A few policies could be implemented to improve the integration of e-skills and e-activities into processes and organizations as follows:

    - Make a plan to attract the e-customers to use e-banking services, using e-programs for learning;
    - Challenge the organizations to develop e-recruitment sites;
    - Develop a policy based on continuous and constant innovation and discover and share new knowledge;

- Find an adequate balance between demand and supply with new technologies;
- Establish an adequate balance of employees with e-skills by sending employees for training to improve e-skills and e-activities;
- Make a constant transfer of technology between generations, and organizations (from the larger ones to the smaller ones, who are the engine for business);
- Develop real policies based on using e-skills and e-activities to generate added and long-term value as virtual activities.

5. Discussion and Conclusions

This paper evaluates the differences between e-skills and e-activities between Romania and the EU28 level and the best-in-class group and analyzes the correlations between e-skills and e-activities among the three presented zones. The findings showed that by using simulation and a mathematical function and Excel data analysis, the specialists could observe a more comprehensive image of the data regarding the impact of e-skills on e-activities (as mentioned above). The research highlighted the existence of important differences between the three analyzed zones at the level of e-activities. The empirical results showed that there is a positive and very strong relationship between the analyzed variables. The results obtained could be important and of real use for specialists in the field, the economy as a whole, and for organizations as well as their employees. The simulation allowed us to see the correlation between the analyzed variables and describe the impact it could have on different EU zones. The model was based on a set of data collected between 2015 and 2019, for three zones, outlining the negative or positive, strong, moderate, or weak correlations between e-skills and e-activities, developed in the new digitized world.

By implementing simulation and modeling, any organization can improve its performance and become sustainable. The benefits of the two processes can be brought into organizations, including the opportunity to work in teams, to work in a virtual world with real results, to analyze real data and behaviors, to observe future simulated data and behaviors, to help identify problems and find timely solutions, to help develop future improvement plans (in our case, to increase the level of e-skills in order to improve e-activities, due to great value of relation), to help achieve objectives and offer results which help forecast changes and challenges, and to forecast performance by determining some possible events, which are easy to implement, modify and test, without risks and costs.

As a result of the analysis of the data presented in the tables above, the following characteristics for each analyzed e-activity are observed:

- For e-skills, the values for e-skills are above average for the EU28 countries (58 in 2019), for Romania, the value is much below the average (31 in 2019), although it follows a positive and increasing trend. For the best-in-class group, an increased trend is observed (values between 70 and 79 for 2019).
- For e-communication by e-mailing, it is observed that the number of sent e-mails is continuously increasing, but according to the table, the data from Romania show that, in 2019, the individuals using the Internet to send and receive e-mails (43) is much below the average for the EU28 countries (74), and much below the analyzed group (90–94).
- For e-commerce, this activity is lower for Romania (33), in 2019, as compared with the average for the EU 28 level (68) and the values obtained for the analyzed group (83–89),
- For e-banking, the average for the EU28 level is 58 (2019), for the four countries from the analyzed group it is between 84% and 91%, and Romania is in penultimate place with 8%,
- For e-recruitment, in Romania, there are still lower values (6 in 2015, 8 in 2017, and 5 in 2019) as compared with the average values from the EU28 (17 in 2015 and 17 in 2019), and the analyzed group (values from 25 to 37 in 2019),

- For e-development, Romania has values between 3 and 4 (2015 to 2019) as compared with the average of the EU28 (6 to 10 between 2015 and 2019), and the analyzed group between 12 and 21 (2015 to 2019) for e-development.

The analysis of the e-skill and e-activity indicators showed that for Romania the values were low as compared with those from the EU28 and from the best-in-class group. We observed low values compared with the values recorded in the group, the difference between them being important (for e-communication 43/94 and for e-skills 31/79) and very important (for e-recruitment 5/37, for e-development 3/21, for e-banking 8/91, for e-commerce 33/89), therefore, hypothesis H1 is completely fulfilled.

To achieve the objective, we also used the correlation between the analyzed variables and Excel data analysis in order to observe the differences among the three established zones for analysis, i.e. the EU28 level, Romania, and the best-in-class group.

The analysis of the correlation for the three analyzed zones showed the following:

- at the EU28 level, there are positive and strong correlations among the analyzed variables, i.e., between 0.76 and 0.98.
- at the Romanian level there are positive, as well as negative or inexistent values, showing a weak, moderate, or strong correlation among e-skills and e-activities. According to the calculation, the least used e-activities in Romania are e-recruitment (having a weak correlation with the e-skills) and e-development (−0.83).
- at the level group, most correlations are high and very high, with the exception of Denmark, although their indicators are high enough as compared with other European countries or the European average.

Analyzing the correlations between e-skills and e-activities, we found that at the EU28 level, there are only strong and positive correlations (between 0.76 and 0.98); at the best-in-class level there are some weak (between −0.78 and -0.01) or average, and most are strong and very strong correlations (till 0.97); and at the Romanian level there are one very weak correlation (−0.81), one weak correlation (−0.29), one nonexistent (0), one average correlation (0.64), and another very strong correlation (0.91). At the Romanian level the correlations are between −1 and +1, and for the analyzed group, most are positive and strong. Thus, H2, i.e., there is a correlation between e-skills and e-activities, is not totally fulfilled because, again, Romania is showing an important gap which must be overcome by strong long-term planning and strong policy activity, as we mentioned above.

Based on this study, future work directions may be taken in consideration by integrating this relationship strength - between e-skills and e-activities - into other applications and not only in a EU zone or group of analysis and comparison, but to other zones, as international or global or other research fields.

Obtaining new e-skills helps achieve sustainable individual and organizational performance by implementing better interdisciplinary team work, to obtain lower costs, greater speed, greater interaction, connectivity, and collaboration, better learning and development, improved processes based on the principle anytime, anywhere, anyhow, and anyone, according to the principle 24/7/365.

A more thorough analysis could be made of each European area, of each European country, or of any situation considered to be important from a macroeconomic or microeconomic standpoint, drawing conclusions, making decisions in order to overcome difficult situations, risks or any problem which could affect the increasing trend of these new forms of digitized activities. This process would not try to replace the traditional processes, but improve them by developing new ways to solve problems, reduce costs, improve processes, achieve better collaboration and relationships, without any borders, anytime, and anywhere.

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Increasing Students' Physical Activity in Function of Social Sustainability: Recommendations from a Social Marketing Perspective

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Abstract: The role of physical activity for social sustainability, as well as potential for social marketing to contribute to increasing the level of physical activity, are already documented in previous literature. Those considerations may gain additional importance in the context of student population, often confronted with the decrease of the level of physical activity, and in a country with scarce similar researches. The purpose of this study is to identify socio-demographic determinants of Serbian students' physical activity. Physical activity was examined as an ordinal dependent variable (inactive, low-frequency activity, and recommended frequency activity) and an ordered logit model was implemented for examining its relations with students' gender, age, household size, emotional status, accommodation, year of study, and living standard. The results show that 15.7% of students are inactive, 22.9% have low-frequency activity, while 61.3% met the recommended level of physical activity. The average probability of physical activity is larger for male students in comparison to female students. Students with better living standards are also more physically active. Finally, the average probability of physical activity decreases starting from students who live with their families, followed by those who live in a private accommodation, to students who live in a dormitory. Considering the obtained results, recommendations from a social marketing perspective are provided.

Keywords: social sustainability; physical activity; social marketing; student population; socio-demographic characteristics; Republic of Serbia

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1. Introduction

The concern for environmental degradation affected the development of the sustainability concept in the 1960s [1]. In that period, the Organisation for Economic Cooperation and Development (OECD) was established with the purpose to increase employment and achieve sustainable economic growth among member countries. In addition, the International Union for the Conservation of Nature (IUCN) made the declaration, which indicates the possibility of economic growth, without harming the environment [2]. Later, in the 1980s, in the report of the United Nations Commission on Environment and Development (UNCED), sustainable development was defined as "a development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [1] (p. 2). From its beginning till today, the concept of sustainability has evolved, relying on at least three main dimensions: economic, environmental and social [2]. Therefore, besides the concern for economic development and environmental protection, sustainability refers to people's ways of living, which should be healthy and satisfying for communities [3].

Social sustainability can be defined as "a positive condition within communities, and a process within communities that can achieve that condition" [1] (p. 23). In this regard, behaviors that lead to poor health, conflicts and emotional distress should be avoided, while all values (such as cultural, family, and knowledge) that contribute to the progress of community, should be protected and nursed [3]. Put differently, "social sustainability means meeting the needs for human well-being" [3] (p. 63).

Although the term wellbeing is rather complex and not easy to define, it is usually related to the fulfilment of human needs [4], which include the physical as well as the emotional and social elements [3]. Among them is exercise [3], i.e., physical activity, which can improve physical and psychological wellbeing [5]. Hereby, relations between physical activity and wellbeing can be explained through its positive effect on health.

Engaging in physical activity can be considered as "one of the primary factors in maintaining sound health in modern society" [6] (p. 116). Its benefits are reflected not only in improving physical health by decreasing risks of diabetes, cardiovascular problems, and various types of cancer, but also in improving mental health by decreasing stress and depression [7].

However, although most of those positive effects are well known, physical inactivity is still one of the biggest health problems worldwide, representing a serious cause of premature death [8]. Contemporary conditions, in which people live and work, have decreased the demand for physical activity, whereby the majority of adults do not perform its sufficient amount required for maintaining good health [6]. In Europe, more than 45% of inhabitants do not engage in exercise or any sport, while only 7% exercise on a regular basis at least five-times weekly [7].

The problem of physical inactivity is of a special importance for young adulthood, especially bearing in mind that this maturation period, often followed by starting college and engaging in academic activities, can be very stressful [9]. Hence, several studies pointed to this issue among the student population. The results of the research in the United States, China, and Canada, showed that half or more of university students did not perform sufficient levels of physical activity [10]. According to the same author, this percentage in Australia was 40%, while in Europe, more than two-thirds of students were inactive. The research which included university students from 23 countries [11], also pointed that physical activity was below the recommended levels in a significant portion of respondents. In the research from the Republic of Serbia, the analysis showed that students did not meet the minimum level of moderate physical activity, which is the most productive for a healthy lifestyle [12].

In order to increase students' physical activity levels and thus improve their physical and mental health, it is necessary to change their behavior. Bearing in mind that change in behavior represents the final goal of social marketing [13], the application of its tools is of a special importance in resolving this issue. Analogously to marketing activities in the private sector, social marketing also involves the development of proper strategy, including "considerations of product planning, pricing, communication, distribution, and marketing research" [14] (p. 5). Hence, within social marketing, after studying the target audience, a social idea needs to be "packaged" in accordance to their desires and wants, and special attention should be dedicated to the analysis of buyers' costs (money costs, energy costs, opportunity costs, and psychic costs), the development of communication-persuasion strategy and tactics (advertising, personal selling, publicity, and sales promotion), and the provision of compatible distribution and response channel [14]. The adequate adoption of social marketing can bring many significant benefits, which refer to the following [15]:

- main role in the development and the implementation of the planned program belongs to the target audience;
- the focus of all program elements is on behavior change;
- the efficiency and effectiveness can be ensured by tailoring influence attempts to interests, wants, and needs of specific target audience segments, as well as groups or individuals within them;
- besides the "simple" promotion of the desired behavior benefits, the influence attempts, through the implementation of the four Ps, are directed to decreasing the behavior costs and making the change in behavior easy and popular.

There are a number of studies about increasing physical activity [16–27], some of them focusing on the student population and the possibilities of social marketing in that process. Some of the social marketing programs for improving physical activity, such as VERB, are marked as successful [22]. Hereby, the already mentioned focus on the target audience in social marketing requires performing market segmentation. The market segmentation presents preconditions for providing recommendations from the aspect of social marketing. The application of market segmentation improves the effectiveness of social marketing's positive influence of physical activity [20]. Market segmentation belongs to social marketing benchmark criteria, whereas the increase of the numbers of those criteria used within the intervention increases the possibility of accomplishing desired behavioral outcomes regarding physical activity [20,21].

Generally, market segmentation can be understood as the identification of individuals or organizations with similar characteristics, with significant implications for determining marketing strategy [28]. In addition, the criteria used for performing market segmentation can be grouped into geographic, demographic, psychographic, and behavioral [29]. Hereby, in previous physical activity determinants researches, it is the social-demographic characteristics that are proven as significant [19,30–38]. Therefore, those characteristics will be used as market segmentation criteria in this research.

Having all previously listed in mind, the following objectives of the research are formulated:

- to explore the influence of socio-demographic characteristics on students' physical activity level in previous research;
- to conduct primary research in Serbia regarding students' physical activity in the context of socio-demographic characteristics;
- to use socio-demographic characteristics in describing profiles of different segments, based on the level of students' physical activity;
- to provide recommendations from a social-marketing perspective.

The obtained results can be significant from several aspects. Firstly, they can contribute to social sustainability issues. Secondly, they can support future similar researches not only in the domestic context, where similar researches are relatively scarce, but in the wider context as well.

2. Literature Review

Because of its importance, students' physical activity has been drawing the attention for many years. The researches were conducted in different countries, among different departments, and usually were focused on examining significant physical activity determinants.

For example, physical activity, exercise and sedentary behaviors were analyzed, taking into account demographic variables of students enrolled in conditioning activity classes [30]. Among the others, their results concluded that men had greater levels of exercise and sedentary (TV/videos and computer) activities than women. Considering age, significant relationships between this variable and variables related to sedentary behaviors and physical activities were found as well. Hereby, younger students were more active when it comes to stretching and vigorous intensity activities, while older students spent more time with computers. In addition, the age analysis was also conducted separately for men and women.

Physical activity levels have also been investigated among medicine and nursing students [31]. The results have shown that 48% and 38% of surveyed nursing and medicine students, respectively, did not meet recommended physical activity levels. When comparing groups of students with low, moderate and high physical activity levels, significant differences were recorded in age, self-efficiency, benefits to barriers ratio, perceived support, and years of study. On the other hand, significant differences were not detected in perceived stress and gender ratio. In the same research, the application of the linear regression model showed that among eight factors (perceived stress, subject discipline, self-efficiency, perceived support, benefits/barriers, gender, age, and year of the degree), only self-efficiency and perceived support had significant positive relationships with the reported level of physical activity.

In another study [32], the physical activity and quality of life (QoL) were examined for sports (SDS) and other department students (ODS). The scores of physical activity and QoL significantly differed between those departments, both in favor to SDS. In regard to gender-specific physical activity levels, significantly higher scores were recorded for men in total, high, medium, and low activities. When it comes to QoL, a significant difference between genders was detected in social relationships, while in other parameters, (physical health, environment, and psychological health) it wasn't the case. Furthermore, the results of the study pointed to the existence of positive relationship between physical activity and QoL levels.

The overall health behavior and its six dimensions, including physical activity, were also examined among Mexican University students at the Psychology School [33]. The subject of the analysis also included their relations with socio-demographic variables. As a separate dimension, physical activity was significantly related to student status, gender, age, marital status, socio-economical level, and mother's education. Hereby, full time students, men, and younger students were more active than part time students, women and students with 25 years or above, respectively. A higher level of physical activity was also recorded for single students, students with a medium-high socio-economic level, and students whose mothers had college education. In addition, when it comes to predicting, the multiple regression model included three variables (gender, marital status, and mother's education), which explained 11.1% of the total variance of physical activity.

Among the others, the influence of socio-demographic factors (gender, age, mother tongue, marital status, and the mother's and father's educational level) on physical activity was examined as one of the lifestyle behavior indicators [34]. According to the results of the research, which involved Swedish university students, significant relations were reported between physical activity and three out of six analyzed factors (gender, father's, and mother's educational level). When considering gender, male students had a higher physical activity score than female students, while in the case of two other factors, physical activity score was positively related to mother's education and it was highest for students whose fathers had a high school diploma.

Similar to previous research, physical activity was considered in the context of lifestyle behavior [35]. The study, realized among university students in Lebanon, showed that a larger percentage of respondents was physically active. In regard to the type of physical activity, more than a half of them did regular walking or running, while the others did exercise (playing games, aerobics, swimming, weight lifting etc.). As expected, male students had higher physical activity rate opposite to female. Moreover, authors analyzed relations between socio-demographic, environmental and lifestyle behavioral characteristics on one side, and health related quality of life (HRQoL), on the other. Hereby, they pointed to the importance of physical activity as a significant determinant of HRQoL.

Socio-demographic and lifestyle determinants of physical activity practice were also investigated among Spanish university students [36]. Following the obtained results, a significantly larger percent of men engaged in sport or physical activities compared to women. When it comes to food, male students who reported to be physically active ate more fruits, potatoes, rice, pasta, meat, and poultry opposite to physically inactive men. On the other hand, in the case of female students, those who were physically active, in addition to fruits, ate more vegetables and legumes. Body Mass Index (BMI), hours of PC, smoking habit and mother's educational level were important determinants of men's physical activity, while age, hours of TV, smoking habit, alcohol consumption, and mother's physical activity practice were significant determinants of women's physical activity. Besides determinants, the authors analyzed physical activity patterns and reasons for not practicing. For both genders, the main motive to practice physical activity was related to working out, i.e., maintaining their fitness. Other reported motives referred to health, enjoyment, affiliation, and others. Additionally, starting university and lack of time were the main reasons for having stopped practicing and not practicing physical activity, respectively.

Physical activity was analyzed among Portuguese university students as well [19]. In the study, the attention was dedicated to the effects of day of a week and gender on daily physical activity levels. For recording the number of steps and time spent in sedentary and physical activities, students were carrying an ActiGraph wGT3X-BT accelerometer during seven consecutive days. The results revealed that both male and female students were physically more active during weekdays in comparison to weekend days. From the aspect of gender, statistical differences in physical activity patterns were found only during weekdays in a way that male students spent more time in physical activities than female students, who, on the other hand, spent more sedentary time.

Undergraduate students from one of the U.S. universities were studied when it comes to changes in eating and physical activity behavior during a period of seven semesters [37]. The minority of students exercised at optimal levels during that period, and within it, there is also a significant decrease. The results pointed to the existence of gender differences since men were more likely to engage in physical activity. However, it should be noticed that men were more likely to engage in sedentary activities as well. Furthermore, the research included into consideration students' accommodation. Hereby, living outside of the campus showed negative influence. Nevertheless, it should be stated that students living with parents were excluded from the research.

In another study, students' physical activity motivation was examined by focusing on two types of physical activity: exercise and sport participation [38]. The analysis of the responses of United States college students revealed that intensity and frequency of exercise engaging were greater compared with sport, while adherence and duration of these two physical activity forms were similar. The authors analyzed 14 motivational variables: strength and endurance, appearance, weight management, stress management, positive health, Ill-health avoidance, health pressure, social recognition, competition, challenge, enjoyment, affiliation, nimbleness, and revitalization. When ranking them, positive health was the most important motive for exercise, and competition was the most important for sport participation. The respondents' rates for all motivational variables were examined in the context of mentioned types of physical activity and gender as well.

A number of socio-demographic characteristics are noticed in previous research [19,30–38]—gender, age, living standard, year of study, accommodation, marital status, student status, mother's and father's education, and mother's tongue. In this paper, students' physical activity was analyzed in relation to several socio-demographic variables: gender, age, living standard, emotional status, household size, year of study, and accommodation. Some of the variables listed in studies abroad were not found as appropriate for domestic context—student status, marital status, and mother's tongue, since almost all students are regular, not in a marriage, and with common culture. Parents' education was also not included since their fundamental education was unified in the period of their growing-up. However, we added some variables as well: emotional status and household-size. Having all previously stated in mind, the following model can be presented (Figure 1).

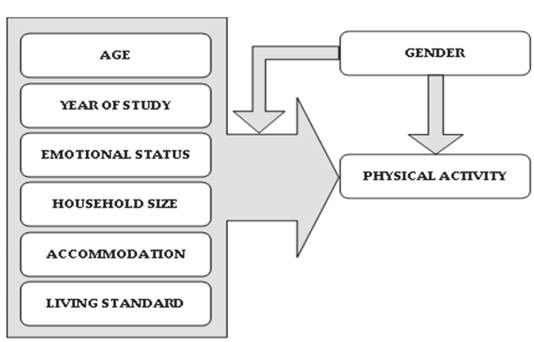

Figure 1. Conceptual model.

The influences of all the independent variables were considered from the gender aspect as well.

3. Materials and Methods

The research based on the convenience sample consisted of 362 students from the University of Novi Sad, Republic of Serbia, and was conducted in 2019 and 2020 (see Table 1).

Table 1. Sample characteristics.

Characteristics		Data
Gender	male	38.10%
	female	61.90%
Emotional status	in a relationship	46.70%
	not in a relationship	53.30%
Accommodation	with family	39.00%
	student dormitory	15.70%
	private accommodation	45.30%
Year of study	first	28.70%
	second	13.30%
	third	25.70%
	fourth	23.50%
	fifth (master)	8.80%
Age	open-ended question	M = 21.46; SD = 1.91
Household size	open-ended question	M = 4.14; SD = 1.04
Living standard	assessed on five-point Likert scale	M = 3.99; SD = 0.84

For measuring physical activity, we relied on the item already used in similar research [11] (p. 183) "whether the individual had taken any exercise (e.g., sport, physically active pastime) in the past 2 weeks". Although the active traveling to work or study could also be considered in this context, the contribution of walking and bicycling for the purpose of transportation amongst students to the overall level of physical activity is very small [11] (p. 188), especially when dormitories are located near the students campuses, as is the case with the University of Novi Sad. Hence, in accordance to the criterion of ACSM (American College of Sports Medicine Position Stand), by which the recommended general level of physical activity refers to exercising 3 or more times a week, i.e., 6 times in 2 weeks [11], all respondents have been divided into three groups: inactive, low-frequency activity, and recommended frequency activity. Besides physical activity, the questionnaire included socio-demographic characteristics, among which three of them were continuous (age, household size, and living standard) and four categorical (gender, emotional status, accommodation, and year of study).

Bearing in mind that physical activity was presented through an ordinal variable, an ordered logit model was implemented for examining its relations with socio-demographic characteristics. In addition, for more detailed analysis, the concept of marginal effects [39] was applied as well. Furthermore, in order to distinguish specific segments, predictive probabilities have been calculated for different combinations of analyzed variables (those that had significant relations with physical activity level segments). Data processing was carried out by the use of STATA statistical package.

4. Results

Generally, when it comes to the level of physical activity, the results of this research show that 15.7% of students are inactive, 22.9% have low-frequency activity, while 61.3% met the recommended level of physical activity. In addition, the results of a logit model are presented in Table 2.

Table 2. Logit model.

Variables	Coef.	Std. Err.	z	P > |z|	[95% Conf. Interval]	
Gender						
female	−0.89	0.24	−3.72	0.00	−1.36	−0.42
Age	−0.12	0.12	−1.03	0.30	−0.35	0.11
Year of study						
2nd	−0.39	0.38	−1.01	0.31	−1.13	0.36
3rd	0.08	0.38	0.20	0.84	−0.67	0.82
4th	0.21	0.57	0.36	0.72	−0.91	1.32
5th	0.22	0.69	0.32	0.75	−1.13	1.56
Emotional status						
not in a relationship	0.18	0.22	0.79	0.43	−0.26	0.62
Household size	0.13	0.11	1.20	0.23	−0.08	0.35
Accommodation						
dormitory	−0.95	0.32	−2.93	0.00	−1.58	−0.31
private	−0.70	0.25	−2.75	0.00	−1.19	−0.20
Living standard	0.44	0.13	3.28	0.00	0.18	0.71
/cut1	−3.06	2.50			−7.97	1.85
/cut2	−1.71	2.50			−6.62	3.19
Number of obs = 362; Log likelihood = −311.07; LR chi2 (11) = 50.19; Prob > chi2 = 0.00; Pseudo R^2 = 0.07.						

The p value of a model equals 0.00 (Prob > chi2 = 0.00), which confirms its statistical significance at $p < 0.01$. As can be seen, at three (gender, accommodation, and living standard) out of seven independent variables, coefficients are statistically significant with p lower than 0.01.

In regard to the living standard, the obtained result (0.44) points to the existence of positive relation between this variable and students' physical activity. Therefore, it can be concluded that students with a better living standard are more physically active.

As two other independent variables with significant coefficients are categorical, we extended the analysis with the concept of marginal effects. The results related to gender are presented in Figure 2.

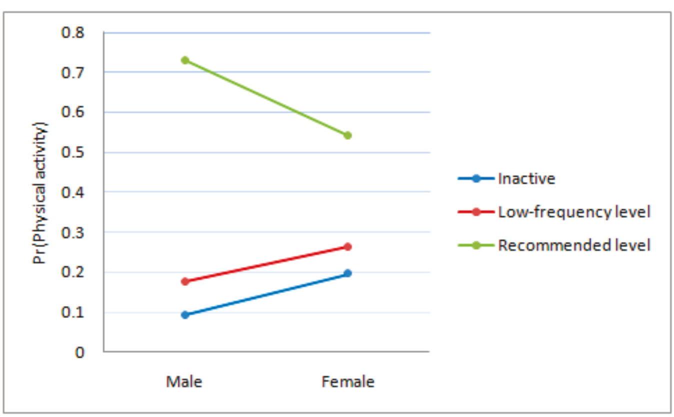

Figure 2. Predictive margins—gender.

In the case of inactive and low-frequency levels, the average probabilities are larger for female students (0.19 and 0.26) in comparison to male students (0.09 and 0.18), whereby their differences of 0.10 (for inactive) and 0.08 (for low-frequency level) are statistically significant with $p < 0.01$. On the other hand, in the case of recommended level of physical activity, the average probability for male students (0.73) is higher than the average probability for female students (0.54), with a statistically significant difference of 0.19.

When it comes to the accommodation (Figure 3), the highest average probabilities for inactive and low-frequency levels of physical activity were obtained for students who live in a dormitory (0.22 and 0.27), followed by those who live in a private accommodation (0.18 and 0.25), and those who live with their families (0.10 and 0.19). Contrarily, the average probability for the recommended level of physical activity was the highest for students who live with their families (0.71), followed by two other student categories, those who live in a private accommodation (0.57), and those who live in a dormitory (0.51).

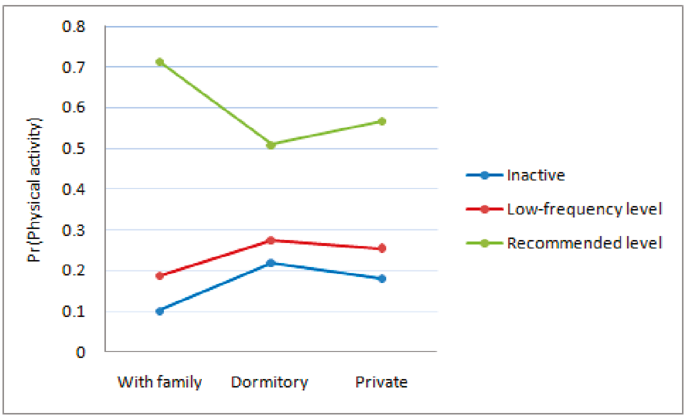

Figure 3. Predictive margins—accommodation.

In addition, the differences in average probabilities of physical activity between these three groups have been examined for all three segments as well. They are shown in Table 3.

Table 3. Marginal effects—accommodation.

Accommodation		Inactive		Low-Frequency Level		Recommended Level	
		dy/dx	P > |z|	dy/dx	P > |z|	dy/dx	P > |z|
With family	dormitory	0.12	0.01	0.08	0.00	−0.20	0.00
	private	0.08	0.00	0.06	0.01	−0.14	0.00
Dormitory	with family	−0.12	0.01	−0.08	0.00	0.20	0.00
	private	−0.04	0.41	−0.02	0.38	0.06	0.40
Private	with family	−0.08	0.00	−0.06	0.01	0.14	0.00
	dormitory	0.04	0.41	0.02	0.38	−0.06	0.40

The differences in average probabilities for all three segments based on physical activity between students who live with their families and two other groups are statistically significant, with $p < 0.01$. On the other hand, the p values for differences in average probabilities between students who live in a dormitory and those who live in a private accommodation were higher than 0.05 in all three physical activity segments. The results considering the influence of independent variables from the gender aspect are shown in Table 4.

Table 4. Marginal effects—gender aspect.

Physical Activity	Gender	Inactive		Low-Frequency Level		Recommended Level	
		dy/dx	P > |z|	dy/dx	P > |z|	dy/dx	P > |z|
Age	male	0.01	0.30	0.01	0.30	−0.02	0.30
	female	0.02	0.30	0.01	0.30	−0.03	0.30
Year of study							
2nd	male	0.04	0.31	0.04	0.32	−0.08	0.31
	female	0.06	0.31	0.02	0.36	−0.09	0.31
3rd	male	−0.01	0.84	−0.01	0.89	0.01	0.84
	female	−0.01	0.84	−0.01	0.84	0.02	0.84
4th	male	−0.02	0.72	−0.02	0.71	0.04	0.71
	female	−0.03	0.72	−0.02	0.71	0.05	0.71
5th	male	−0.02	0.75	−0.02	0.75	0.04	0.75
	female	−0.03	0.75	−0.02	0.75	0.05	0.75
Not in a relationship	male	−0.01	0.43	−0.02	0.43	0.03	0.43
	female	−0.03	0.43	−0.01	0.43	0.04	0.43
Household size	male	−0.01	0.24	−0.01	0.23	0.02	0.23
	female	−0.02	0.23	−0.01	0.23	0.03	0.23
Accommodation							
dormitory	male	0.08	0.02	0.10	0.00	−0.18	0.01
	female	0.14	0.01	0.08	0.00	−0.22	0.00
private	male	0.05	0.01	0.07	0.01	−0.12	0.01
	female	0.09	0.00	0.06	0.01	−0.16	0.00
Living standard	male	−0.04	0.00	−0.04	0.00	0.08	0.00
	female	−0.06	0.00	−0.03	0.00	0.10	0.00

As can be seen in Table 4, there are no larger differences in their values between male and female. Predictive probabilities for different combinations of significant independent variables can be seen in Table 5.

Table 5. Predictive margins—combinations.

Variables			Inactive		Low-Frequency Level		Recommended Level	
Gender	Accommodation	Living Standard	Margin	P > |z|	Margin	P > |z|	Margin	P > |z|
male	with family	1	0.17	0.01	0.27	0.00	0.55	0.00
male	with family	2	0.12	0.00	0.22	0.00	0.66	0.00
male	with family	3	0.08	0.00	0.17	0.00	0.75	0.00
male	with family	4	0.05	0.00	0.12	0.00	0.82	0.00
male	with family	5	0.03	0.00	0.09	0.00	0.88	0.00
male	dormitory	1	0.35	0.00	0.32	0.00	0.33	0.00
male	dormitory	2	0.26	0.00	0.31	0.00	0.43	0.00
male	dormitory	3	0.18	0.00	0.28	0.00	0.54	0.00
male	dormitory	4	0.13	0.00	0.23	0.00	0.64	0.00
male	dormitory	5	0.08	0.00	0.18	0.00	0.74	0.00
male	private	1	0.30	0.00	0.32	0.00	0.38	0.00
male	private	2	0.21	0.00	0.29	0.00	0.49	0.00
male	private	3	0.15	0.00	0.25	0.00	0.60	0.00
male	private	4	0.10	0.00	0.20	0.00	0.70	0.00
male	private	5	0.07	0.00	0.15	0.00	0.78	0.00
female	with family	1	0.34	0.00	0.32	0.00	0.34	0.00
female	with family	2	0.25	0.00	0.31	0.00	0.44	0.00
female	with family	3	0.18	0.00	0.27	0.00	0.55	0.00
female	with family	4	0.12	0.00	0.22	0.00	0.66	0.00
female	with family	5	0.08	0.00	0.17	0.00	0.75	0.00
female	dormitory	1	0.57	0.00	0.26	0.00	0.17	0.01
female	dormitory	2	0.46	0.00	0.30	0.00	0.24	0.00
female	dormitory	3	0.35	0.00	0.32	0.00	0.32	0.00
female	dormitory	4	0.26	0.00	0.31	0.00	0.43	0.00
female	dormitory	5	0.18	0.00	0.28	0.00	0.54	0.00
female	private	1	0.51	0.00	0.29	0.00	0.20	0.00
female	private	2	0.40	0.00	0.31	0.00	0.29	0.00
female	private	3	0.30	0.00	0.32	0.00	0.38	0.00
female	private	4	0.21	0.00	0.29	0.00	0.49	0.00
female	private	5	0.15	0.00	0.25	0.00	0.60	0.00

When it comes to the inactive category, the highest average probability (0.57) refers to female students who live in a dormitory, with low living standard (1 out of 5). As for students with low frequent level of exercise, there are several profiles with an average probability of higher than 0.30 to belong to this segment: female, living with families, assessing standard with 1 or 2, female living privately with standard marked with 2 or 3, female living at dormitory, with living standard assessed with 3 and 4, male living in dormitory with assessed standard of 1 and 2, male living privately and evaluating standard with 1. The largest probability (0.88) to be active can be noticed for men, living with families and assessing standard with 5.

5. Discussion and Conclusions

When it comes to the level of Serbian students' physical activity, it should be noticed that 15.70% of students are inactive, 22.90% have low-frequency activity, while 61.30% meet the recommended level of physical activity. The results suggest that almost 40% of the students exercised less than six times in two weeks before the interviewing. Those relatively negative tendencies are partly in accordance to the previously described situation worldwide [7,10,11], as well as in Serbia [12].

Having previous results in mind, as well as the significance of physical activity for social sustainability, some general recommendations can be provided. Positive influence of celebrity endorsers are already proven in the literature especially when they are famous because of sport [16]. In the concrete case, trying to cooperate with Novak Djokovic could be a good idea. He is, at the moment of writing this paper, the world tennis player number one at ATP list, and is also Serbian and very popular within the country. When it comes to suggestions regarding student population, there can often be identified the stress on education: "changes to current college physical education programs" [6] (p. 124), "paying attention to the health education and the behaviors related to the health promotion" [17] (p. 205). However, if relying dominantly on the university in that process, the special caution should be paid at implementation of intervention measures [18]. Some other recommendations rely on providing low-cost programs of physical activity or bicycles [19].

However, in addition to general recommendations, within this research is conducted market segmentation. Not only that the research is focused on a specific segment of population, but it is additionally segmented regarding socio-demographic characteristics. The obtained results can be compared to some of the previous research. Hereby, out of seven independent variables—students' gender, age, household size, emotional status, accommodation, year of study and living standard, only three had significant influence, two of them at 0.10 level. The three variables that had significant influence are gender, accommodation, and living standard. Concretely, the average probability of physical activity is larger for male students in comparison to female students. That is in accordance with the results of some previous studies [19,30,32–37]. On the other hand, the existence of gender differences is not always confirmed in the literature [31]. Furthermore, the students with better living standard are also more physically active, what is in accordance to previous research [33]. Finally, the average probability of physical activity decreases starting from students who live with their families, followed by those who live in a private accommodation, to the students who live in a dormitory. The existence of the difference in the context of students' accommodation is in line with some of the authors [37], although their results are in favor of living on the campus. However, the comparability of the results is limited due to exclusion of students living with parents from their research. The highest activity of students living with parents in this research can be explained by the smallest change in life when started studying in comparison to other segments, and having the largest amount of free time because of relying on parents for performing certain activities in the house.

Contrarily, students' age, household size, emotional status, and year of study are not proven as significant predictors of physical activity in this research. The absence of the influence of age is in line with the studies [31] (when applying linear regression model) [34], but is not in accordance to other studies [30,33,36] (in the last case, for females). The lack of influence of the year of study is in accordance to [31] (when applying linear regression model), but not with [37]. Emotional status not influencing physical activity was proven in this research in line with [34], but in contrast to [33].

The description of the profiles of marketing segments led to several conclusions. Firstly, the greatest probability to be inactive can be noticed in the case of women living in dormitories and having very low living standard. However, weakly active students belong in most of the cases of women, living in different places, and assessing living standard with lower and higher marks. When men belong to this segment, they always have low standard and do not live with their families. Finally, most physically active are men living with families and have high living standard.

Starting from the descriptions of the segments, there is a need to target each of them. In the case of active students, the stress should be on maintaining their level of activity. When it comes to students being less active or inactive, they should be tried to be translated to more active segments in each of the cases.

From the context of marketing mix, several recommendations can be provided. As a starting point can be used, the means-end approach to consumer behavior, meaning consumers are not interested in products per se, but are interested in them regarding the way the product helps them attain their life values [40]. Hereby, physical activity can be presented as a mean for accomplishing different ends. Having in mind that it is the case of younger population, there is a great possibility (although additional studies should confirm this hypothesis) that being healthy is still not the primary focus of their interest, since it is usually immanent to their age. However, "being attractive" or "having a good time with friends" or "being interesting and adventurous" or "being strong and successful" can be of more interest to them and motivate them to spend their time in accomplishing those goals. Launching a campaign named, for example, "People inspired with me" (with ambiguous meaning—being inspired together or being inspired by) and asking the students to post Instagram photos when having physical activity with friends can fulfill if not all, but most of the listed goals. Providing equipment for being active can be of special importance—free bicycles, gyms under the open sky, balls for different sports, or even walking routes. As a part of the campaign, the participants can be given designed shirts or hats. Besides, the number of likes could be understood as non-monetary incentive. An application offering students information about places nearby where they can accomplish "being attractive," "having a good time with friends," "being interesting and adventurous," or "being strong and successful" by being physically active and having content available at those places could also be helpful. Engaging students from faculty of sport to show other students different options of physical activity might be useful. In addition to using social networks, direct contact with a target audience is possible. From the beginning of the studies, faculties could provide students information about accomplishing quality of life, including possibilities of performing physical activities. Such information could increase the popularity of the faculties and bring them more interested students, with whom communication can be performed by using, among others, e-mail marketing in accordance to permission marketing approach [41].

Some of the recommendations from researches abroad might be appropriate to be implemented in domestic conditions, as well, especially in the case of students' segments being less physically active. For example, bearing in mind that for people with a lower living standard, certain physical activity contents are less accessible, they can be attracted with incentives in the first period of intervention (free period, novel activities). Informing them about it can be done in a classical manner, since in the subsequent phases, there would be increasing influence of word-of-mouth, which is expected to be stronger if the number of participants recruited at the beginning was larger [23]. Community-based interventions had a positive effect not only in case of population with lower living standard [23,24], but for women as well [25]. Wearable technology is already proven to be successful for increasing physical activity of women [26], so it might be appropriate to inform them how to measure the level of their physical activity by using disposable technology. In this regard, activities of ambush marketing, to which attention is being paid in domestic conditions as well, can be used [42]. For example, under the billboard which promotes some possibility of physical activity, there could be added information about disposable free wearable technology.

It should be noticed that communication with all those segments can be performed directly, and by using online and offline marketing communication channels. The possibilities of identifying such segments on social networks are great. Besides leaving the information about the gender when creating profiles, the living standard can often be predicted considering the devices by which is being logged-in to profiles, while at the same time information about changing the place of living are also available, together with frequent check-ins at certain places, including dormitories. However, there should be taken into account conclusions from previous research that "solely Web-based intervention seems to be ineffective in promoting PA among universities students" and that "face-to-face lifestyle modification interventions have greater effects than Web-based interventions" [27] (p. 1608). Finally, considering a social marketing approach, it is of great importance to provide adequate monitoring regarding all previously described issues.

Future research may measure physical activity more precisely, include other determinants in addition to socio-demographic (especially lifestyle), reach larger and more representative sample, and monitor the participants through time. In addition, consultations with representatives of the country/city/university/sponsors could be performed in advance for obtaining their opinion about suggested intervention.

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The Impact of Education and Residential Environment on Long-Term Waste Management Behavior in the Context of Sustainability

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Abstract: Currently, the problem of waste reduction is a permanent concern for all countries of the world, given the need to ensure the sustainability development. In this context, the research aims to highlight the impact of education and demographic factors by residence areas on the long-term behavior of the amount of waste generated in 29 European countries during 2013–2017. The study is based on statistical and econometric modeling aimed at identifying, testing and analyzing the existence of long-term correlation between the amount of waste per capita recorded in each country and four factors of influence considered significant for waste reduction: *Pupils and students by education level* and *Classroom teachers and academic staff by education level*, representing exogenous variables which quantify the educational outcomes, as well as *The population by degree of urbanization* (cities, rural areas), as demographic factors. As a result of an analysis based on correlation and regression method, a cointegration relationship between the analyzed variables was identified. Considering the amount of waste as an important component of the environmental pressure, the obtained results show the significant long-term effect that education and the demographic factor can have on its long-lasting behavior, as well as the ways through which these factors can act to strengthen sustainability.

Keywords: sustainability; waste; education; degree of urbanization; cointegration model; Vector Error Correction models; autoregressive vector patterns

1. Introduction

Worldwide and implicitly at the European level, the issue of waste reduction is increasingly being addressed in the context of sustainable economic and social development of any country. This aspect takes into account the fact that sustainability is an integral component in the development strategy of each individual company and society as a whole, because it manifests itself in the interrelated plan between the three parts: economic, social and environmental. Closely interdependent with the environment, the evolution of waste is also closely linked to the strategic policy of preventing its generation and favoring recycling, so that the decision of prescriptive regulations or educational campaigns could be taken [1].

The concept of "waste" is oriented, on the one hand, to products that are at the end of the production and utility life cycle, and on the other hand to construction and demolition, production and trade processes. Manufacturing each product includes a significant amount of waste during the life cycle, highlighting all the impacts and types of pressures exerted: thus, the impact on soil degradation, emissions, etc. occurs in the procurement of raw materials; the impact of production is signaled through the use of materials and energy, air and water emissions, solid waste, etc., and the impact of transport—through raw materials and products directed to the final markets [2].

The education of young people in the field of environmental protection both in family and in schools is a priority, representing an efficient way to reduce the amount of waste [3]. In this direction, studies have been carried out [4–6] certifying the importance of education and training in the field of environmental protection, raising public awareness of environmental responsibility, minimally invasive environmental lifestyles based on recycling and waste reduction, essential components for sustainability.

Liu and Wu [7] identified three main components in the waste management process: urban economy and urban development (where the urban population has the highest share), energy consumption and urban scale. At the same time, other important studies have shown that the amount of waste is directly influenced by the residential environment of households, with significant differences according to the location of the household (in rural or urban areas) [8–10].

In this context, the present research was designed to find out whether there is a long-standing relationship between the amount of waste in each country—as an endogenous variable—and the exogenous variables represented by the population of each country by urbanization degree (cities, towns and suburbs, rural areas), pupils and students by education level and classroom teachers and academic staff by education level, respectively, thus representing a strategic point of using and modeling the evolution of the waste amount, in the direction of its diminishing.

Taking into account that education on waste management starts from the first years of life, inside the family, and continues to be enhanced with each level of school education, two variables have been introduced into the study reflecting how education in pre-university and university field influences the fluctuation of the amount of waste in the direction of its reduction: Pupils and students by educational level and Classroom teachers and academic staff by education level. At the same time, the existence of significant differences in the behavior of generated waste in relation to the location of the rural or urban household has led to the need to consider the population by degree of urbanization (cities, rural areas) as exogenous variables.

The paper is organized in six sections. The first section—Introduction—presents briefly aspects of the context of addressing the impact of education and demographic factors by residential areas on the long-term waste behavior, in the context of sustainability. This was completed by the second section, which includes the literature with the presentation of many results of studies, through which several points of view of both the interested persons and the specialists dealing with waste management were highlighted in the context of the sustainability phenomenon. Section 3 describes the methodology used to identify the influence of the level of education and the degree of urbanism on the long-term waste evolution, a methodology that includes building and validating cointegration models.

The analysis—whose results are presented in Section 4—is based on statistical data on waste evolution, population by degree of urbanisation (cities, rural areas), pupils and students, respectively classroom teachers and academic staff by education level, in the EU states and Iceland.

The paper finally includes two sections (Discussion and Conclusions) summarizing the results of the analysis and outlining aspects of managerial possibilities and proposals regarding the impact of factors in reducing the amount of waste in the future.

The main objective of the analysis was to identify how the studied variables can lead to an improved waste management in the context of sustainable development at European level, given that the integrated and sustainable waste management capacity must be a top priority and overcome technical issues to embrace the various vital elements of sustainability [11].

2. Literature Review

According to Directive 2008/98/EC of the European Parliament, waste is "any substance or object which the holder discards or intends or is required to discard". The Directive establishes and regulates the ways of reducing or preventing possible adverse impacts from waste generation and management [12]. However, since it is necessary to increase the sustainability of the waste management process by promoting the principles of the circular economy, this directive has been modified by the adoption of Directive 851/2018. It aims at adopting additional measures on sustainable production and consumption, covering the whole life cycle of products and setting new, more ambitious, objectives for European countries to move towards a circular economy [13]. A correct and effective approach to waste management can lead to progress in meeting the Millennium Development Goals [14].

There is a lot of research highlighting the aggravation of the problem of generated waste, a problem that threatens the very human-environment relationship itself. A solution to this issue, provided by the studies, is to set up a rigorous waste management plan as an important tool for developing environmental policies by different countries, in order to reduce greenhouse gas emissions [15] towards a transition to a more circular economy [16,17]. One component of this plan is to predict as much as possible the quantities of municipal waste generated [18]. The authors of this study have used multiple regression models applied to panel data on 38 urban and rural localities in the New York area to estimate the amount of residential municipal solid waste, based on independent variables in the climatological, demographic, socio-economic, cost and distance dimensions.

Kolekara et al. [19] have shown some negative aspects in the efficient and accurate determination of the amount of waste generated, including the lack of sufficient data, especially in developing countries and especially in rural areas, as well as the high degree of uncertainty. They present the main existing models used in estimating the amount of waste generated on the basis of economic, socio-demographic or management factors. Thus, as we will see below, many studies identify as a factor with significant action on waste generation a number of households' characteristics: household size, household income and the level of education. Often the application of the identified models is limited to certain regions and depends on the way the waste flows are selected.

Kawai et al. [20] assessed the confidence level and comparability of the various models used in estimating the quantities of municipal solid waste generated per capita. The level of socio-economic development and the environmental policies of some regions generate differences in the amount of municipal solid waste per capita. A low degree of comparability of per capita waste estimation models may come from the use of definitions of the concept of solid municipal waste, different from country to country. The low efficiency of waste data collection or migration flows between urban and rural areas can also affect the confidence of these models, especially in developing countries.

Another direction on which many specialized studies have been focused is the identification of the determinants, of the main factors affecting the waste generation process. Thus, an important share of the total waste generated by the population is the food waste [21,22]. Chalak et al. [23] analyzed the impact of legislation and economic incentives on the amount of food waste generated by households, based on data covering 44 countries.

Significant variations in the amount of food waste between countries with different levels of development and incomes were noted. The results of the analysis highlighted the higher impact of legislative regulations, policies and strategies in the field on the improvement in the amount of waste generated, compared to fiscal measures.

Significant regional differences in the amount of waste generated per capita are addressed and explained by Saladia [24] in terms of the seasonal population which is normally not taken into account in determining the amount of waste in a given region. The author's analysis reveals that per capita waste is positively correlated with the relative contribution of the tertiary sector to GDP creation and negatively correlated with the population over 64 years. The analysis does not certify that there is a significant correlation between waste generated and per capita income. The demographic factor itself is, however, an important one in modeling the behavior of the waste generation process [25], the applied model highlighting a direct correlation between the amount of waste and the population density.

Another category of studies addresses different components of waste generation (institutional, residential and commercial) [26–31]. Thus, the analysis by Hockett et al. [32] highlighted that retail sales (including restaurant, grocery and clothing sales) and disposal taxes have a significant impact on waste generation. However, the research did not reveal a significant link between industry, construction, personal income, urbanization and waste generation.

Among the determinants of waste generation, urbanization is the one around which many studies have focused, analyzing its impact on the amount of waste generated [33]. According to Ugwuanyi and Isife [34], the weaknesses of the waste management process are: infrastructure precariousness, legal and political framework, environmental issues management, budgetary constraints, overcapacity, environmental education insufficiency, issues which are—to a large extent—related to the degree of urbanization.

The significant direct impact of the increase in the demographic factor and the rapid development pace on the efficiency of the municipal solid waste management system are addressed by Pai et al. [35]. The results of the study show that an increase in the population leads to an exponential increase in the amount of municipal waste generated.

Another category of studies and research focuses on the importance and impact of education on the waste generation process. Thus, Fredrick et al, Sinthumule and Mkumbuzi, and Al-Khatib, et al. [36–40] identify some of the means of educating and raising awareness among urban communities about the waste management process: involving active organizations in education, NGOs and private companies, public meetings, media use, household head training. Analysis based on a cross-sectional, multistage survey has demonstrated the positive effect of public education on optimizing and streamlining urban waste management, but also draws attention to the insufficiency of education provided in the field of waste separation and organic waste management, which represents more than 50% of the total amount of waste generated in major cities.

Knowledge acquisition in the field of waste recycling, reuse, recovery and composting can be achieved even at younger age at school. Therefore, Rada et al. [3] illustrates the role of education provided to young people in the field of environmental protection, amplified by the example they can offer to their families as a way to optimize household waste management. The study covered educational units at different levels of education (primary, secondary, high school) and analyzed the influence of youth age and typology of educational and informational activities on household behavior in waste management. Research results show that waste production depends on the size of the educational institution (expressed as the number of pupils and teachers), on the types of activities carried out outside the teaching hours, and on the habits of the household members.

Also, research has highlighted the way in which households and their socioeconomic characteristics influence the waste management system [41–48]. Using probit regression models, Handayani et al. [49] showed that the level of education and knowledge gained, as well as the income level have a significant influence on household waste management behavior. At the same time, the authors have demonstrated the existence of regional disparities between urban and rural areas in waste management practices. Households whose members have a higher education level and income and are located in the urban area are more likely to increase the amount of waste generated, but also have a higher probability of managing their waste amount, compared to households in rural areas which, generally, have a lower level of education and income. The positive correlation between the educational level of the household members and the generation of waste within it is in line with the results of some studies, like: Sujauddin et al., Thi Thu Nguyen et al., Fang et al., Jörissen et al. [50–53]. Age and gender also generate significant differences in households' behavior regarding waste management, with women and older people displaying greater responsibility than men and young people. Similar results were also obtained by Li et al. [54] and Limbu [9], which also identified a negative correlation between the educational level of family members and the amount of waste generated within the household. A positive correlation between household income and the amount of waste generated was identified by Zia et al. [55], who also studied the influence of seasons on waste generation. The conclusion was that this process is more pronounced, more intense in spring and winter [56,57].

The residential area of households has a significant direct influence on waste generation (Skourides et al. [8]; Liao [58]), so changing the household location (rural and urban) leads to a significant increase in the amount of waste generated [9,10]. Other variables positively correlated with the amount of waste generated by households are: household size, family members' availability to spend their leisure time outside the household, consumption pattern and household income. Based on the application of a logistic regression model to the data obtained from a sample of 402 respondents, Afroz et al. [5] concluded that household size and income are significant determinants of the amount of waste generated by households, while the age and education of family members can significantly influence their availability to waste recycling. Emerging from the need to improve negative pressures exerted by human activity on the environment, researchers' studies focused on the differences in the waste management system by the location of the household (urban or rural area). Thus, Han et al. [59] and Marshall and Farahbakhsh [60] study the factors influencing waste generated in rural areas and the peculiarities of this process in developing countries. The explanatory variables included in the study were of economic nature (household income and expenditure, types of energy and fuels used and types of existing industries in the rural area), social (population, education and culture) and natural (temperature, precipitation, humidity, harvesting periods). These factors determine the waste content and consumption patterns and can be used as ways in the optimization and improvement of the waste management system.

Daban Astane and Hajilo [61] carried out a quantitative and qualitative analysis of the waste generated in rural Iranian areas on a sample of 318 households, pointing out that about 70% of the average amount of waste generated per person per day is organic waste, 30% being solid waste. It is noted that there are patterns in the waste spatial distribution, with significant differences in the amount of waste generated in the north and northwest areas, areas with significantly higher rates of waste generation than others. The most important determinants of waste generation are household income, assets, the age and attitude of household members towards environmental issues, while behavior and knowledge related to resource efficiency are significant factors in reducing the amount of waste generated.

3. Methodology and Data

Taking into account the objective of the study—identifying the long-term relationship between the amount of waste generated per capita and a number of factors influencing their evolution in 29 European countries during 2013–2017, as well as highlighting the similarities and the differences between them, regarding the indicators analyzed—four explanatory variables were selected. These variables, together with the explained variable, represent the five sets of data on which the study is based (Table 1). The datasets were provided by EUROSTAT and processed with Eviews program.

Table 1. List of variables used in the analysis.

Variable Notation	The Variable	Measurement Unit
W_POP	Amount of waste per capita	t/inhabitant
PSE	Pupils and students—as % of total age population	%
TS_POP	Classroom teachers and academic staff	people/100 inhabitants
POP_C	Population total median equivalised income—Cities	%
POP_R	Population total median equivalised income—Rural Areas	%

Source: Authors' selection, based on EUROSTAT data.

The methodology applied in the study started with the analysis of the main characteristics of the variables included, as well as the identification of the correlation matrix between them.

In analyzing the dynamics of economic processes and systems, frequently occur situations in which the endogenous variables are placed both on the left and right side of the equations of the respective economic models. In these cases a possibility of analysis is the use of Vector Autoregressive Models (VAR), as well as Vector Error Correction (VEC).

Given the complexity of the interdependencies between the variables included in the analysis and the necessity of highlighting the cointegration relationships between them, starting from the matrix $V \in R^{k \times n}$ (where k represents the number of endogenous variables and n—the lengths of the data series), the following model were generated: VAR models—for the analysis of the interdependent time series and the effects of perturbations on the values of the variables involved, and VEC models—for identifying the cointegration relationships between the variables.

The general form of a VAR model is:

$$y_t = \sum_{i=1}^{p} A_i \cdot y_{t-i} + B \cdot x_t + \varepsilon_t \tag{1}$$

where y_t is a vector of k endogenous variables, x_t is a vector of m exogenous variables, and $A_i \in R^{k \times p}$, $B \in R^{k \times m}$ are coefficients matrices to be estimated.

VEC models are derived from VAR models and are designed to restrict the long-term behavior of endogenous variables by incorporating cointegration relationships in VEC models, so as to converge to them by allowing short-term adjustments. The term "*cointegration*" is called "Error Correction Term" (ECT), as it allows estimating and correcting short-term deviations from the long-term equilibrium of the studied phenomenon.

One of the most commonly used methods for estimating VEC models is Generalised Method of Moments (GMM), the Arellano, M. and Bond, S. (1991) [62] estimator being applied in the analysis of various growth models.

In the research we started from a VEC model whose general form is:

$$\Delta y_t = \beta \cdot ECT_{t-1}^{y} + \sum_{i=1}^{p} A_i \cdot \Delta y_{t-i} + u_t \tag{2}$$

In Equation (2) $\Delta y_t = y_t - y_{t-1}$ is a vector of k endogenous variables, $A_i \in R^{k \times p}$ are coefficients matrices to be estimated and $\beta \in R^k$ is the vector of ECT coefficients.

Taking into account the relation (2) and the data series included in the matrix V, the corresponding VEC model has the following form:

$$\begin{aligned}\Delta W\_POP_t = {} & \beta_1 \cdot ECT_{t-1} + \sum_{i=1}^{p} \alpha_{1,i}^{W\_POP} \cdot \Delta W\_POP_{t-i} + \sum_{i=1}^{p} \delta_{1,i}^{PSE} \cdot \Delta PSE_{t-i} \\ & + \sum_{i=1}^{p} \delta_{1,i}^{TS\_POP} \cdot \Delta TS\_POP_{t-i} + \sum_{i=1}^{p} \phi_{1,i}^{POP\_C} \cdot \Delta POP\_C_{t-i} + \sum_{i=1}^{p} \gamma_{1,i}^{POP\_R} \cdot \Delta POPR_{t-i} + u_{1,t}\end{aligned} \tag{3}$$

$$\begin{aligned}\Delta PSE_t = {} & \beta_2 \cdot ECT_{t-1} + \sum_{i=1}^{p} \alpha_{2,i}^{W\_POP} \cdot \Delta W\_POP_{t-i} + \sum_{i=1}^{p} \delta_{2,i}^{PSE} \cdot \Delta PSE_{t-i} \\ & + \sum_{i=1}^{p} \delta_{2,i}^{TS\_POP} \cdot \Delta TS\_POP_{t-i} + \sum_{i=1}^{p} \phi_{2,i}^{POP\_C} \cdot \Delta POP\_C_{t-i} + \sum_{i=1}^{p} \gamma_{2,i}^{POP\_R} \cdot \Delta POPR_{t-i} + u_{2,t}\end{aligned} \tag{4}$$

$$\begin{aligned}\Delta TS\_POP_t = {} & \beta_3 \cdot ECT_{t-1} + \sum_{i=1}^{p} \alpha_{3,i}^{W\_POP} \cdot \Delta W\_POP_{t-i} + \sum_{i=1}^{p} \delta_{3,i}^{PSE} \cdot \Delta PSE_{t-i} \\ & + \sum_{i=1}^{p} \delta_{3,i}^{TS\_POP} \cdot \Delta TS\_POP_{t-i} + \sum_{i=1}^{p} \phi_{3,i}^{POP\_C} \cdot \Delta POP\_C_{t-i} + \sum_{i=1}^{p} \gamma_{3,i}^{POP\_R} \cdot \Delta POPR_{t-i} + u_{3,t}\end{aligned} \tag{5}$$

$$\Delta POP\_C_t = \beta_4 \cdot ECT_{t-1} + \sum_{i=1}^{p} \alpha_{4,i}^{W\_POP} \cdot \Delta W\_POP_{t-i} + \sum_{i=1}^{p} \delta_{4,i}^{PSE} \cdot \Delta PSE_{t-i} + \sum_{i=1}^{p} \delta_{4,i}^{TS\_POP} \cdot \Delta TS\_POP_{t-i} + \sum_{i=1}^{p} \phi_{4,i}^{POP\_C} \cdot \Delta POP\_C_{t-i} + \sum_{i=1}^{p} \gamma_{4,i}^{POP\_R} \cdot \Delta POPR_{t-i} + u_{4,t} \quad (6)$$

$$\Delta POP\_R_t = \beta_5 \cdot ECT_{t-1} + \sum_{i=1}^{p} \alpha_{5,i}^{W\_POP} \cdot \Delta W\_POP_{t-i} + \sum_{i=1}^{p} \delta_{5,i}^{PSE} \cdot \Delta PSE_{t-i} + \sum_{i=1}^{p} \delta_{5,i}^{TS\_POP} \cdot \Delta TS\_POP_{t-i} + \sum_{i=1}^{p} \phi_{5,i}^{POP\_C} \cdot \Delta POP\_C_{t-i} + \sum_{i=1}^{p} \gamma_{5,i}^{POP\_R} \cdot \Delta POPR_{t-i} + u_{5,t} \quad (7)$$

A first condition in modeling and testing the causal relationship between the five endogenous variables involves testing the stability of the data series. For this, Unit Root Test of Augmented Dickey-Fuller test was used. The Null Hypothesis states that X (the analyzed variable) has a unit root. The validation condition is to reject the Null Hypothesis for 5% significance level (α = 0.05).

Testing the existence of cointegration relationships was carried out with the Johansen Cointegration Test [63], (for which the Null Hypothesis states that there are no cointegration relationships). If this second Null Hypothesis is also rejected, the VEC model (or models) is generated and the statistical significance of the parameter values is tested. In (3) the conditions are $\alpha_{1,j}^{W\_POP}, \delta_{1,j}^{PSE}, \mu_{1,j}^{TS\_POP}, \phi_{1,j}^{POP\_C}, \gamma_{1,j}^{POP\_R} \neq 0$, $(\forall) j \neq 0$ and they are similar to the conditions for Equations (4)–(7).

A second important condition for validating the model is to ensure the system convergence to balance. For this, the ECT coefficient should be negative ($\beta_1 < 0$) and statistically significant for the significance level chosen. For this, the t-statistics test was used.

After identifying the general form of the ECT, its parameters have to be statistically significant. This condition is also checked using the t-statistics test. Confidence level used was 95% (α = 0.05). In some situations, a 90% confidence level (α = 0.10) was also accepted.

For checking the stability conditions, autoregressive roots graph, as well as the model response to unit impulses applied to its variables are displayed and analyzed.

The methodology used throughout the paper produced results that have led to a clearer picture of the impact of the urbanization process and institutional education on past, present and future evolution of waste amount, in the countries included in the analysis.

4. Results

Achieving the objective of finding a way in which the management of the analyzed variables can lead to sustainable waste management and address sustainable European development, requires an approach based on the main features of the variables included in the analysis, as well as the correlation matrix, presented in Table 2.

The results of partial correlations show that the W_POP variable is correlated with the other variables (all correlation coefficients being statistically significant), although the correlation between W_POP and TS_POP is poor. Taking this into account, we will consider W_POP as the main variable in the analysis performed. At the same time, it can be inferred that the PSE, TS_POP and POP_C variables can be considered as independent variables in the first phase, which can influence W_POP. As for the POP_R variable, although the results may indicate a possible endogenousness between POP_C and POP_C, it can be solved by generating the VEC model.

Using VEC models requires prior determination of the integration order. The results obtained by applying the Augmented Dickey-Fuller (ADF) test are presented in Table 3. These lead to the conclusion that series are 1st order integrated and suitable for further cointegration testing.

Table 2. Main characteristics of the analyzed variables and the correlation matrix between them.

	W_POP	PSE	TS_POP	POP_C	POP_R
Mean	0.407152	21.37928	1.757995	39.28739	32.77387
Median	0.412586	20.30000	1.838117	36.10000	34.70000
Maximum	1.182873	31.40000	2.870871	90.40000	56.20000
Minimum	0.191658	17.50000	0.551509	13.00000	0.100000
Std. Dev.	0.138738	2.988497	0.522968	14.10623	13.05356
Observations	112	112	112	112	112
W_POP	1.000000				
	-				
PSE	0.464211	1.000000			
	(0.0000)	-			
TS_POP	0.189715	0.228380	1.000000		
	(0.0461)	(0.0004)	-		
POP_C	0.321884	0.057580	0.032029	1.000000	
	(0.0027)	(0.5483)	(0.7386)	-	
POP_R	−0.378688	−0.191441	−0.018805	−0.677338	1.000000
	(0.0000)	(0.0145)	(0.8447)	(0.0000)	-

Table 3. Augmented Dickey-Fuller test statistics.

D(W_POP)		D(PSE)		D(TS_POP)		D(POP_C)		D(POP_R)	
t-Stat	Prob.	t-Stat	Prob.	t-Stat	Prob.	t-Stat	Prob.	t-Stat	Prob.
−10.83	0.000	−11.18	0.000	−7.86	0.000	−10.43	0.000	−10.22	0.000
Test critical values: −3.490772 ***; −2.887909 **; −2.580908 *									

*** 1% level, ** 5% level, * 10% level

In order to determine the co-integration order of VAR (p)—type process between the series in the level, there have been used the information criteria of Akaike (AIC), Schwarz (SC) and Hannan-Quinn (HQ), as well as Final Prediction Error and sequential modified LR statistical test (LR). All the other criteria (Table 4) suggest the order of the VAR process q = 1. Taking into account that the stationarity of the series was obtained by a 1^{st} order differentiation, the chosen process will be VAR (2).

Table 4. Results regarding the establishment of the order in the VAR process.

VAR Lag Order Selection Criteria						
Endogenous variables: W_POP PSE TS_POP POP_C POP_R						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	−926.1369	NA	224.4159	19.60288	19.73730	19.65720
1	−770.6526	291.3284 *	14.40106 *	16.85585 *	17.66233 *	17.18173 *
2	−754.1369	29.20688	17.29282	17.03446	18.51302	17.63191
3	−746.1053	13.35776	24.99076	17.39169	19.54232	18.26071
* indicates lag order selected by the criterion						
Each test at 5% level						

Considering the results obtained above and using Johansen's (1988) approach, the existence of three cointegration equations (Table 5) for the chosen significance level was highlighted. At the same time, however, the Max-Eigen Statistic values for 5% significance level indicate the existence of a single regression equation, which includes the five variables considered as endogenous ones.

Taking into account the fact that the Max-Eigen Statistic is more restrictive, the intention was to identify the model that co-integrates all five variables included in the analysis. Testing their endogeneity was performed with the Pairwise Granger causality test (Null Hypothesis: the variables analyzed cannot be exogenous variables in the model) and their belonging to the model was verified using Lag Excluding Tests (Null Hypothesis: the analyzed variable is not excluded from the model).

Table 5. The results of Cointegration Rank Test.

Unrestricted Cointegration Rank Test (Trace)					Unrestricted Cointegration Rank Test (Maximum)			
Hypoth. No. of CE(s)	**Eigen Value**	**Trace Statistic**	**0.05 Critical Value**	**Prob.****	**Hypoth. No. of CE(s)**	**Max-Eigen Statistic**	**0.05 Critical Value**	**Prob.****
None *	0.2821	98.2859	76.9727	0.0005	None *	34.78528	34.6905	0.0489
At most 1 *	0.1938	63.5006	54.0790	0.0058	At most 1	22.62919	28.5881	0.2391
At most 2 *	0.1836	40.8715	35.1927	0.0110	At most 2	21.29950	22.2996	0.0685
At most 3	0.1132	19.5720	20.2618	0.0620	At most 3	12.62394	15.8921	0.1526
At most 4	0.0640	6.94806	9.16454	0.1292	At most 4	6.948063	9.16454	0.1292
Lags interval (in first differences): 1 to 2					* denotes rejection of the hypothesis at the 0.05 level			
Trace test indicates 3 cointegrating eqn(s) at the 0.05 level					** MacKinnon-Haug-Michelis (1999) *p*-values			
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level								

The results of Pairwise Granger causality (Table 6) lead to accepting the Null Hypothesis for all five variables. Thus, in the case of the dependent variable D(W_POP) that reflects the change in the volume of waste per capita per time unit (year), as a result of the change in one time unit of the Pupils and Students as % of total age population, Classroom teachers and academic staff, Population total median equivalised income—Cities, Population total median equivalised income—Rural Areas, the individual probabilities corresponding to the values of the $\chi 2$ statistic (Chi-square) and the value corresponding to the model as a whole (Prob = 0.7894) are higher than the 5% significance level ($\alpha = 0.05$). The same conclusion is reached for the other four variables.

Table 6. The results of VEC Granger Causality test.

Dependent variable: D(W_POP)			Dependent variable: D(PSE)			df
Excluded	**Chi-sq**	**Prob.**	**Excluded**	**Chi-sq**	**Prob.**	
D(PSE)	1.1881	0.5521	D(W_POP)	0.7669	0.6815	2
D(TS_POP)	0.2389	0.8874	D(TS_POP)	1.0993	0.5771	2
D(POP_C)	3.4708	0.1763	D(POP_C)	0.2063	0.9020	2
D(POP_R)	2.0618	0.3567	D(POP_R)	0.1836	0.9123	2
All	4.6969	0.7894	All	2.6027	0.9568	8

Dependent variable: D(TS_POP)			Dependent variable: D(POP_C)			Dependent variable: D(POP_R)			df
Excluded	**Chi-sq**	**Prob.**	**Excluded**	**Chi-sq**	**Prob.**	**Excluded**	**Chi-sq**	**Prob.**	
D(W_POP)	1.2353	0.5392	D(W_POP)	0.1720	0.9176	D(W_POP)	0.6387	0.7266	2
D(PSE)	4.5637	0.1021	D(PSE)	0.7143	0.6996	D(PSE)	0.2923	0.8640	2
D(POP_C)	3.6037	0.1650	D(TS_POP)	0.8618	0.6499	D(TS_POP)	0.5196	0.7712	2
D(POP_R)	3.0890	0.2134	D(POP_R)	1.5575	0.4590	D(POP_C)	0.5200	0.7710	2
All	10.048	0.2616	All	3.3028	0.9139	All	1.6624	0.9897	8

The above tests highlighted the existence of a model in which all five variables are considered endogenous. To exclude or include them from the VEC model, the critical value of the Chi-squared statistic, for 5% significance level ($\alpha = 0.05$) and 5 degrees of freedom whose value is 11.070498 was taken into account.

The results of the Lag Exclusion Wald Tests (Table 7) show that all Chi-squared test statistics for both DLag_1 and DLag_2 are strictly lower than the critical value (11.0705). Consequently, the Null Hypothesis is accepted. It follows that none of the variables will be excluded from the model. The same conclusion is reached by analyzing *p_value* values, which are significantly higher than the chosen significance level.

Table 7. VEC Lag Exclusion Wald Tests.

	D(W_POP)	D(PSE)	D(TS_POP)	D(POP_C)	D(POP_R)	Joint
DLag 1	4.625024 [0.463332]	1.008971 [0.961839]	8.533598 [0.129177]	0.975558 [0.964513]	0.488963 [0.992522]	20.94764 [0.695526]
DLag 2	2.139070 [0.829587]	1.068857 [0.956823]	5.832351 [0.322875]	1.777931 [0.878939]	2.437144 [0.785930]	13.91055 [0.963269]
df	5	5	5	5	5	25

Numbers in [ ] are *p*-values

Taking into account the obtained results, the VEC model, which includes all five analyzed variables, was generated (Table 8). Testing the model validity and the statistical significance of its parameters was performed with the Student (t) test. In the case of this model, for the significance level chosen, the critical test value is 1.98238. Since the value of CointEq1 constant (coefficient β_1 in Equation (3)) is negative (−0.007086) and statistically significant (t-statistics = −2.33718 > t-critic = 1.98238), the VEC model is statistically significant. Also, since all the t-statistic values of the model coefficients are higher than the critical value, it follows that the Null Hypothesis is rejected and the Alternative Hypothesis is accepted. All coefficients are statistically significant.

Table 8. The estimation of VEC coefficients and their Standard errors and t-statistics values.

Cointegrating Eq:	CointEq1	Standard Errors	t-Statistics
W_POP(-1)	1.000000		
PSE(-1)	0.648967	(0.15372)	[4.22178]
TS_POP(-1)	4.076959	(0.81624)	[4.99479]
POP_C(-1)	−0.135140	(0.03740)	[−3.61348]
POP_R(-1)	−0.135135	(0.03988)	[−3.38871]
C	15.93563	(4.50194)	[3.53972]
Error Correction:	D(W_POP)		
CointEq1	−0.007086	(0.00530)	[−2.33718]

Regarding the stability of the VEC model, this is highlighted on the one hand by how the analyzed model reacted to the application of a unit impulse on its variables, and on the other hand that all the roots of the characteristic polynomial are included in the unit circle (Figure 1).

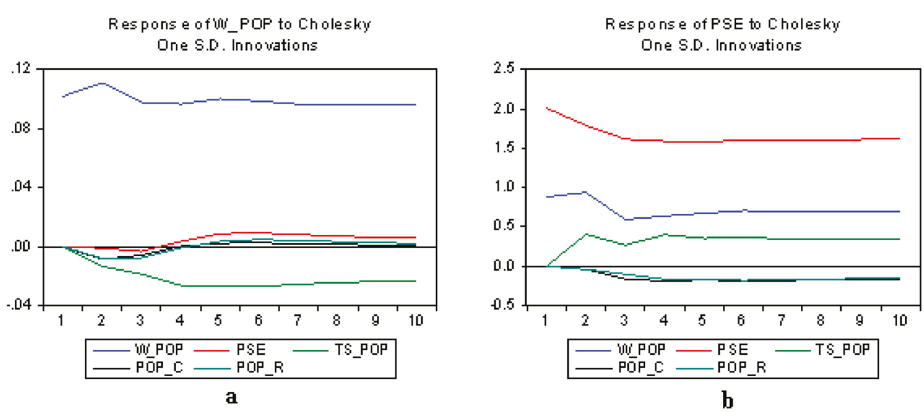

Figure 1. *Cont.*

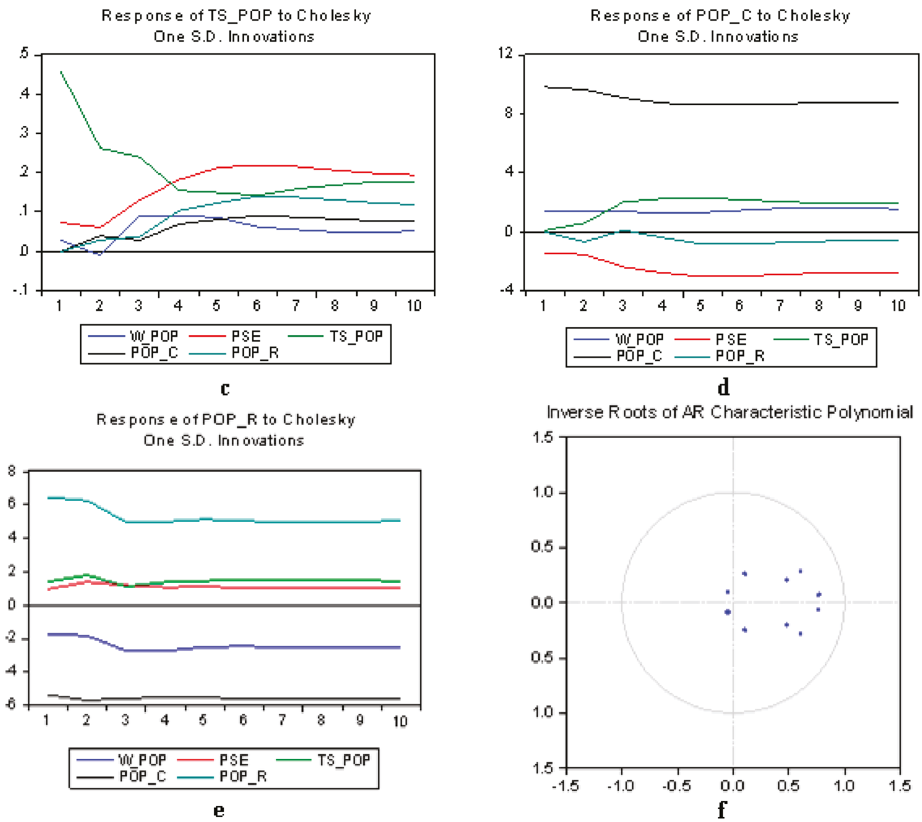

Figure 1. Response of W_POP (**a**), PSE (**b**), TS_POP (**c**), POP_C (**d**), POP_R (**e**) to Cholesky One S.D. Innovations, and Inverse Roots of AR characteristic polynomial (**f**).

The long-term relation, corresponding to the Error Correction Term (ECT_{t+1}), based on Equations (3)–(7) has the following form:

$$
\begin{aligned}
d(W\_POP) = \; & -0.007 \cdot (W\_POP_{t-1} + 0.649 \cdot PSE_{t-1} + 4.077 \cdot TS\_POP_{t-1} - 0.135 \cdot POP\_C_{t-1} \\
& -0.135 \cdot POP\_R_{t-1} + 19.936\,) + 0.107 \cdot W\_POP_{t-1} - 0.142 \cdot W\_POP_{t-2} - 0.005 \cdot PSE_{t-1} \\
& -0.005 \cdot PSE_{t-2} + 0.004 \cdot TS\_POP_{t-1} + 0.012 \cdot TS\_POP_{t-2} - 0.003 \cdot POP\_C_{t-1} \\
& -0.0005 \cdot POP\_C_{t-2} - 0.002 \cdot POP\_R_{t-1} - 0.0009 \cdot POP\_R_{t-2}
\end{aligned} \tag{8}
$$

The long-term relationships of Error Correction Term (ECT1), based on Equations (3)–(7) is:

$$
\begin{aligned}
W\_POP = \; & -0.6489 \cdot PSE - 4.0769 \cdot TS\_POP \\
& +0.1351 \cdot POP\_C + 0.1351 \cdot POP\_R - 19.9356
\end{aligned} \tag{9}
$$

The regression coefficients show the long-lasting reverse connection between the amount of waste and Pupils and students—as % of the total age population, respectively Classroom teachers and academic staff per 100 inhabitants, meaning that an increase in the education level leads to a reduction in the waste amount. As for the other two factors (Population total median equivalised income—Cities, Population total median equivalised income—Rural Areas), their influence on the amount of waste is direct, without a significant long-term difference between urban and rural areas. It follows that the education level is a primordial factor, which can act favorably to sustainable development.

5. Discussions

Considering that, in time, limitations exist regarding the complete and detailed analysis of the amount of waste generated, mainly due to difficulties in data collection [19], the paper addressed the issue of waste quantity behavior, by studying the interdependence level of two categories of factors: educational and demographic, by degree of urbanization, at the level of 29 European countries.

In this context, an autoregressive vector model, followed by a Vector Error Correction model have been applied, on 2013–2017 data, referring to pupils and students, classroom teachers and academic staff by educational level and the population by degree of urbanization (cities, rural areas).

Analyzing the long-term relationship between the amount of waste, education and the demographic factor by residence area, it is pointed out that the amount of waste is reduced as the level of education increases and is increased with the demographic factor, taking into account the existence of insignificant difference by the two types of residence areas.

Regarding the first factor (the educational one), it is noted that at institutional level sustainable development can be addressed through the upgrading of the educational waste recycling-oriented process, in order to improve the protection and the quality of the environment, through increasing the competence of the services provided, resulted in well-trained graduates, both theoretically and practically.

Currently, more and more employers are looking for graduates with sustainable education. They need to know the aspects of sustainability and to have the skills to use them in their professional work.

At both institutional and social levels, universities can be seen as having an important role in the community. At the same time, students can demonstrate they are the most important agents of change, both in the environment and in society, that they have environmental, social and economic knowledge about sustainability and that they have a new system of values, motivation and other abilities to produce change.

Regarding the second factor (the demographic one, by residence area) it is noted that in many low-urbanization areas there is no uniform, equal distribution of solid waste collection services, but there is a hierarchy of rural localities according to their financial strength to provide solid residential waste collection services, as well as some informal features of governance (such as involving local wealthy families in local governance) [64,65].

The solid municipal waste recycling system in developing countries highlights that sustainable solid waste management is a concern for the mankind as a whole and is also addressed in the United Nations Millennium Development Goals, as a way of reversing the negative impact of human activity on environment [66]. Therefore, adequate management of solid waste should be addressed in order to reduce poverty, reduce child mortality and improve the population health. While large-scale sustainable solid waste management methods are used in developed countries, it is advisable in developing countries to take over and use these methods on an increasing scale.

The system may include an economic and financial mechanism that respects the general principles, especially "the polluter pays" principle and the subsidiarity principle. In addition, the integrated waste management system should also consider promoting information and awareness system for all actors involved in the action, as well as a modern system for obtaining complete and accurate data and information, adequate to national and European reporting requirements.

6. Conclusions

A major challenge for sustainable development is how to encourage activities that positively influence the environment and discourage those which cause environmental damage [67]. As waste is an important component of the environmental pressure exerted by humans, the capacity to manage the activities of waste amount reduction is a priority task in managerial strategies.

In this context, in order to capture future waste behaviour (as a measure of sustainability), starting from the 2013–2017 data, two factorial plans were addressed: education (pupils and students by education level and classroom teachers and academic staff by education level) and demographic, by degree of urbanization (cities, rural areas). The research was conducted at the level of 29 EU countries. The innovative contribution of the article consists of combining the educational and demographic factors by residential areas, as well as the statistical indicators selected for the quantification of the two factors. At the same time, originality also consists in the fact that the applied model analyzes the long-term implication of these factors on the quantity of waste generated, a less discussed aspect in other specialized studies.

Applying the Vector Autoregressive Model and Vector Error Correction Model led to a long-term relationship between waste quantity, education and demographic factor by residence. At the same time, this relationship shows the reduction of the waste quantity is significantly influenced by the increase of the educational level, while the demographic factor, due to the insignificant difference between the two types of residence environments, determines the increase of the waste amount.

In this context, it is possible to highlight the way in which we can manipulate each factor so that to encourage an improvement in the waste management process.

The educational factor puts the spotlight on the educational institutions. Thus, they must have the capacity to allocate resources intelligently on the one hand to become sustainable, and on the other hand to provide learners (pupils, students) with a living experience in a sustainable environment. At the same time, they must be the catalyst for the changes that are expected and demanded at the society level as a whole, but also by their graduates in order to become tools for the society transformation towards sustainable development.

As a conclusion, it can be said that both pupils and students must have many of the attributes needed to act as agents of change and need to be trained as active citizens to boost and sustain the global economy.

Regarding the demographic factor by urbanization degree, the comparative analysis of the data shows the waste management system in low and middle income countries is less developed in rural areas than in urban areas, a fact also confirmed by other studies in the literature [68,69]. The main problems of the waste management system in rural areas in less developed countries are: lack of political and financial tools that can be applied to improve waste management, lack of long-term vision of waste management policy, lack of elementary measures, which have long been applied in developed countries, lack of funds, lack of environmental responsibility, poor quality of waste management services [70]. There are significant differences in the coverage of waste collection services between major cities and rural areas in less developed countries [71], while in developed countries these services cover entirely the rural areas.

In this context, it is necessary to act in the future on the main factors with a significant influence on the waste management system: the existence of legislative regulations in the field, the application of incentive schemes, the cost of waste management procedures, the budgets allocated for this purpose, education and knowledge of the importance of waste collection, household income, availability of local population to pay waste collection and evacuation taxes, existence of markets based on recycled materials, involvement of companies and small businesses in the waste management process. It is also recommended to conduct awareness and accountability programs for urban population, focused on the need to reduce the amount of waste, by periodically evacuating and recycling the waste generated.

Designing and applying innovative solutions that should be both resource efficient and waste management systems add value to business and contribute to sustainability. In this way, we can talk about an improvement in operations management and environmental management, that can be integrated at operational level and include the waste management supply chain.

The implementation of an integrated waste management system requires the adaptation and development of an institutional and organizational framework, for the introduction of national requirements and harmonization with European structures.

The authors intend to extend the analysis by identifying other variables with significant impact on the evolution of the amount of waste generated, as well as forecasting it for a future period, by considering other typologies of econometric models. As the model is limited to European countries, the authors wish to analyze the pattern of the relationship between the amount of waste generated, the level of education and the environment of residence also in non-European countries.

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Social-Psychological Determinants of Serbian Tourists' Choice of Green Rural Hotels

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Abstract: The significance of green rural tourism for sustainable development is widely recognized. In addition, a number of researches attempt to explain the green choice among tourists. Hereby, different theoretical approaches are used. The dynamic approach to the Theory of Planned Behavior (TPB) is implemented in this study. The approach considers that the influence of different elements of TPB (attitudes, subjective norms, perceived behavioral control) on intention to visit green rural hotels is tested in the context of different phases in behavior change of the respondents (pre-decision, pre-action, action). According to the authors' knowledge, this is the first implementation of the dynamic approach to the TPB in understanding green rural choice. During data analysis, multigroup structural equation modelling (SEM) was used. The results indicate that the existence and the strength of the influences of the elements of TPB are different in different phases of behavior change. Managerial implications for the studied market (Serbia) are also provided within the paper.

Keywords: sustainable development; rural tourism; green hotels; theory of planned behavior; behavior change; market segmentation

1. Introduction

Tourism represents a great strategy for encouraging and improving economic development, not only in developing, but in developed countries as well [1]. It made up 9.8% of global Gross Domestic Product (GDP) and contributed to the global economy with $7.61 trillion USD in 2016 [1]. The analysis of the World Travel and Tourism Council (WTTC), which included 184 countries, has shown that the tourism sector generated 284 million workplaces, meaning that 1 out of 11 workplaces in the world comes from the tourism sector [2]. The ways in which its development affects other sectors (such as forestry, food processing, agriculture, livestock raising, fishing, and handicrafts) can improve the entire community's well-being [3]. Moreover, under the influence of several factors, including life dynamics, the increasing progress and higher knowledge level, people's desire and possibility to travel and discover will only increase in future [2]. This can be related to the prediction from the World Tourism Organization (WTO), according to which 1.8 billion people will be engaged in tourism by 2030 [1].

Tourism development does not bypass rural areas either. In contrast to urban areas, which are more utilitarian and materialistic, the countryside represents a strong evocation of a way of life and is usually observed "as a better physical and social world" [4] (p. 1). Rural tourism has a long history in most Western countries and there is written evidence related to the increased interest of middle and higher classes in visiting rural areas, dating back to the 19th century [5]. In Germany, paid holidays for civil servants and white-collar workers were organized more than 100 years ago [6]. They were spent in the countryside, near cities, in inexpensive privately let rooms or smaller hotels, usually in the hillier areas. Since that period, rural tourism, as a new type of tourism developing in Europe, has been satisfying the demands of people who want to get out of the cities and enjoy the quiet countryside [7].

Considering the explanation of rural tourism, "it can be broadly defined as tourism which takes place in rural areas" [8] (p. 47). In relation to this definition, previously mentioned authors raise the question about the term rural, which may differ among countries and cultures. For that matter, certain common characteristics, such as a small portion of land under buildings and low population densities can be used [8]. When it comes to the distinction between rural and urban areas, the former should be characterized by four main qualities [4] (p. 3):

- relatively lower level of physical densities related to people, activities, and buildings;
- lower level of cultural and social heterogeneity;
- lower level of economic diversity;
- comparative physical apartness from general political, economic, and social networks.

In order to accurately define rural areas, it can be referred [9] to the methodology commonly applied by the Eurostat and the OECD (The Organization for Economic Co-operation and Development), based on which "rural area, or rural population, are defined as an area, or population, of local communities/municipalities, with density of less than 100 inhabitants per 1 square kilometer" (p. 264). The additional distinctiveness lies in people's views and images of the countryside, which are different from those of the city and are based on two interrelated dimensions (personal responses to the countryside and its popular social representations) [4].

By drawing tourists to rural areas, this type of tourism has become a relevant factor in rural development, strengthening not only rural, but urban areas' profits, as well [7]. In rural areas, tourism can also bring certain positive sociocultural effects, including development of the local economy and its independence, reinvestment in cultural resources, the increase of respect for local communities, reinforcement of cultural traditions and the increase of toleration and compromise among different cultures [10]. However, bearing in mind that rural tourism depends on numerous factors, such as cultural and natural resources, interpretative facilities, infrastructure and tourist offer in terms of accommodation, services, and goods, its inappropriate regulation can lead to threats to culture, social structures, and the physical environment [11]. Thus, special attention should be dedicated to its managing and development.

Considering rural tourism and development, there can be identified three different viewpoints [10]. From the first one, tourism is employed as a strategy for rural development, whereby, new strategies should be created in order to renew or change rural areas threatened by the decline of agriculture and the decay of villages. For this purpose, complementary activities could be developed, addressing their human and natural resources. From the second viewpoint, tourism is considered as a policy related to renewing rural zones, by reducing dependency on agriculture and turning to new business opportunities. The last (third) point of view refers to rural tourism as an important asset of sustainable development. Bearing in mind its direct relationships with nature, rural culture, and values, and thus its potential environmental and cultural effects, the analysis of rural tourism in regard to sustainability has been drawing the attention of many researches [10].

The concept of sustainable development became known after the Brundtland Report from 1987, in which it was described as satisfying the present needs without influencing the future generations' capacity to fulfil their own needs [2]. The paradigm of sustainability, based on three different aspects (economic, social, and environmental), has been used in various areas of knowledge and life [12], affecting the tourism industry as well [13]. The first ideas of sustainable tourism appeared under the pressure of visitors on countryside communities [4] in Central Europe, among French-, Italian-, and German-speaking areas [14]. This was most notably in the Alpine mountain regions, due to the increase of summer vacationing and intensive winter sports. Since then, many initiatives and projects within sustainable tourism have been related to the countryside [4]. Therefore, sustainable tourism, contrary to artificial tourism theatre intended for exploitation, can proffer the authentic countryside lifestyle, i.e., "real scenario, where life is realistic and nature can be preserved by the same local inhabitants and hosts at the same time" [12] (p. 557).

Following the definition of the United Nations, sustainable tourism represents a type of tourism which pays full attention to its current and future social, economic, and environmental effects, taking into account the needs of visitors, the environment, the industry, and host communities [1]. A similar explanation is given by the World Tourism Organization, according to which models of sustainable tourism must be focused on the needs of current tourists and the recipient region, as well as on the protection of resources, all in order to ensure future opportunities [15]. Regarding the definition of sustainable tourism development, there can be stressed a view that tourism development should be in line with the principles of sustainable development and the local economy, respecting the natural environment permanence and local community's good, from both an ethical and social aspect [13]. There are three main goals related to the sustainable development of the tourism sector: ecological, economic, and social [13], whereby all three types of interests need to be balanced, even in the case when said balance is not provided or automatic [15]. In order to ensure the mentioned balance, in the context of sustainable tourism, the focus should be on [16]:

- the optimum usage of natural resources, sustaining crucial ecological processes, and preserving biodiversity and natural heritage,
- respecting the host communities' sociocultural authenticity, protection of traditional values and cultural heritage, and tolerance among different cultures,
- providing sustainable long-term business and socioeconomic utilities, ensuring stable employment level, income opportunities, and welfare for local communities, and reduction of poverty,
- sustaining a high level of tourist satisfaction, spreading awareness of sustainability, and promotion of this type of tourism.

Although there is a great potential of rural tourism to foster economic development and local economy diversification, considering its relations and respect to the natural and social environments, there are also some potentially negative consequences associated to environmental and social effects in rural tourism, which depend on several factors such as the number of tourist arrivals, environmental fragility, local culture steadiness, etc. [15]. Having that in mind, an option is to aim for green tourism, which presents "an important component of sustainable tourism" [17] (p. 66) and can be, besides resort tourism, "a form of rural tourism" [18] (p. 135). To this can be added that "one of the more important recent innovations in the tourist sector" that gained "increasing prominence" [19] (p. 300) in previous years, especially at some markets, are green hotels. In the literature, there is often offered the explanation of the Green Hotels Association, according to which a green hotel is "an environmental friendly lodging property that institutes and follows ecologically sound programs/practices (e.g., water and energy savings, reduction of solid waste, and cost saving) to help protect our planet" [20] (p. 325). Although from previous explanations it can be seen that green hotels do not have to be necessarily correlated to rural areas, they can also be associated to a green form of rural tourism.

A number of researches have used the Theory of Planned Behavior (TPB) in explaining green hotel choices. Furthermore, that theory was implemented wider—for predicting different green choices [21]: organic food and products, recycled products, green toys, eco-car, green-certified products, etc. The theory originally includes [22] attitudes towards behavior (formed in the relationship between beliefs and evaluation of beliefs), subjective norms (social pressure on people to behave (or not) in a certain way), and perceived behavioral control (perception of own ability to perform certain behavior). Hereby, those variables predict intention to perform behavior. Furthermore, that variable, together with perceived behavioral control, influence actual behavior.

There can be identified several manners of the use of the Theory of Planned Behavior in the explanation of green hotel choices. On one hand, there is implementing solely the elements of original theory. On the other hand, there is extending the theory with additional variables, often from other theoretical approaches (since there can also be noticed the use of other theories (e.g., the Model of Goal-directed Behavior or the Values–Beliefs–Norms (VBN) theory [23]) in the sustainable tourism field). Furthermore, some methodological aspects should be considered in TPB implementation—for example, the dynamic approach [24], or asymmetrical modelling [25].

Having all previously explained in mind, the main goal of this paper is to implement the dynamic approach to the Theory of Planned Behavior for explaining green hotel choices within rural tourism offer. According to the authors' knowledge, this is the first such implementation of TPB in predicting intention to visit green hotels, not only in the context of rural tourism, but in general as well. Besides elaborating basic issues regarding rural tourism, green tourism, green hotels, sustainable development, and their mutual relation, this paper provides a review of previous implementations of TPB in green hotels choice. Furthermore, the results of the primary research conducted in Serbia are also presented.

2. Literature Review

In recent years, in accordance with environmental concerns and cost reductions, the number of green hotels is increasing [26]. In addition to the business sector, green hotels have become the object of attention in the scientific field as well. Hereby, there are a number of studies which refer to the examination of customers' intention and behavior related to visiting green hotels. This field of interest is of special importance, especially bearing in mind that, despite great attention and publicity dedicated to environmentalism, it still has a low priority for customers [27].

A study conducted in the U.S. [20] used the variables from TPB—attitude, subjective norm, and perceived behavioral control (affected by behavioral, normative, and control beliefs, respectively, as well as evaluations of those beliefs)—to explain intention to visit a green hotel. The model showed appropriate fit (better in comparison to using some of the elements in the context of the Theory of Reasoned Action), which was additionally improved when adding the influence of subjective norm on attitude. Although the research included moderation analysis as well (the comparison of the strength of described influences between customers that actively practice ecofriendly activities and those who do not perform it in such a manner), there were no significant results from it.

A research from Taiwan [28] extended explanation of intention to visit a green hotel by adding past behavior to independent variables from TPB. Furthermore, the influence of that variable on intention to visit a green hotel was hypothesized to be both direct and indirect (through attitude, subjective norm, and perceived behavioral control). Finally, authors expected that influence of subjective norm and perceived behavioral control on intention to visit a green hotel is also mediated by attitude. The results confirmed the significance of all the relations except the influence of perceived behavioral control on attitude.

Another study from Taiwan [19] extended TPB with altruism. Hereby, the authors showed that intention to visit a green hotel is directly influenced by attitude, subjective norm, perceived behavioral control, and altruism, whereas there were also indirect influences on that variable from subjective norm (through attitude) and altruism (through attitude, and perceived behavioral control).

Environmental education presents a variable by which TPB was also expanded in a research in Taiwan [29]. Hereby, it is expected that it influences intention to visit green hotels both directly, and mediated by behavioral beliefs determining attitude, normative beliefs determining subjective norm, and control beliefs determining perceived behavioral control. While the authors succeeded in documenting the influence of appropriate beliefs on elements of TPB, the influence of those elements on visit intention, as well as indirect influence of environmental education, they did not confirm the direct influence of environmental education on visit intention.

Intention to visit a green hotel is once again examined in a study in Taiwan [30], but this time by adding perceived moral obligation to its antecedents together with attitude toward visiting a green hotel, subjective norms, and perceived behavioral control. Furthermore, all those variables mediate the influence of environmental concern on intention to visit a green hotel. Authors confirm all listed influences to be significant.

The extension of TPB with additional variables in a study conducted in the U.S. [31] showed better fit with the data and greater explained percentage of the variance when explaining revisit intentions of a green hotel. Besides the influence of the elements from TPB—attitude, subjective norm, and perceived behavioral control (caused by behavioral, normative, and control beliefs, respectively)—on revisit intention, that variable is also being influenced by customer satisfaction, overall image, and frequency of past behavior. Furthermore, a variable service quality is modeled as antecedent for both customer satisfaction and attitudes, while there is also an influence of subjective norm on attitude. Not only did the results regarding the extended model show superior predictive power, but also, all the hypothesized relations were statistically significant.

A research in India [32] expanded TPB in predicting green hotel visit intention with two additional constructs—moral reflectiveness and conscientiousness. Hereby, the added variables influence the dependent variable, both directly and indirectly (through the variable attitude). The results showed that all the hypotheses derived from the described model were supported.

When it comes to extending TPB with several (or all) elements from other theoretical approaches, there is evidence [33] that its combination with VBN theory provides superior prediction power in comparison to the separate usage of TPB, VBN, or the Norm Activation Model. That research was created to understand intentions regarding green lodging. It was performed on the sample of respondents from the U.S. Firstly, there were expected positive influences of attitudes towards the behavior, subjective norms, and perceived behavioral control on behavioral intention, with the moderating role of non-green alternatives' attractiveness in all those relations. The model also included variable adverse consequences for valued objects. It was influenced by biospheric value mediated by ecological worldview. Furthermore, it affected all independent variables from TPB, as well as behavioral intention mediated by, in a following order, ascribed responsibility and obligation to take pro-environmental actions. Obligation to take pro-environmental actions is also influenced by subjective norms, while mediation (regarding non-green alternatives' attractiveness) is studied considering the influence of that variable on dependent variables as well. The results confirmed the significance of all presented influences, whereas all of them were positive. Hereby, the strongest influence on behavioral intention can be assigned to variables' adverse consequences for valued objects, subjective norms, and sense of obligation to take pro-environmental actions. Furthermore, the influences of independent variables from TPB as well as of obligation to take pro-environmental actions were stronger when non-green alternatives' attractiveness was lower.

In a research conducted in India [34], TPB was combined with the Attitude–Behavior–Context (ABC) Theory to explain travelers' intentions to stay in green hotels. Besides psychological factors from TPB, the model includes contextual factors: biospheric value, green trust, and willingness to pay a premium. Hereby, perceived behavioral control, subjective norm, and willingness to pay a premium affect dependent variable only directly. Attitude and green trust influence dependent variable both directly and indirectly (through willingness to pay a premium in the first and willingness to pay a premium and all psychological variables in the second case). Biospheric value determines dependent variable only indirectly (through willingness to pay a premium, green trust, and all psychological variables). The results confirmed most of the hypothesized relations with the exception of the influence of biospheric value on willingness to pay a premium and subjective norm, the effect of subjective norm on intention to stay in green hotels, and the influence of the attitude on willingness to pay a premium.

In a study which attempted to explain the choice of nature-based tourism destinations in Taiwan [35], TPB is combined with the technology acceptance model, Value–Belief–Norm theory, and social identity theory. Besides all the relations taken from the original TPB, the model includes perceived ecotourism usefulness (from the technology acceptance model), biospheric value (from the Value–Belief–Norm theory), and ecotourism self-identity (from the social identity theory) as direct antecedents of environmental attitude, and indirect antecedents of ecotourism behavioral intention and ecotourism behavior. Furthermore, ecotourism self-identity also influences subjective norms directly and ecotourism behavioral intention and ecotourism behavior indirectly, while biospheric value effects ecotourism behavior directly. All hypothesized relations were confirmed except the existence of the influence of ecotourism self-identity on environmental attitude. Furthermore, the integrated model was shown to be superior in comparison to the use of the single models.

A research conducted in the UK [36] considers the elements of TPB within the stimulus–organism–response framework, together with elements of the norm-activation theory, and social identity theory. Hereby, the authors consider the influence of green hotel attributes (presented as a higher-order formative construct consisting of five reflective first-order dimensions: customer benefit, energy efficiency, recycling policy, water efficiency, and green landscape) through personal route and social route. In the first case, the influence of those attributes on attitude toward green hotels, intention to stay at green hotels, and willingness to pay a premium is mediated by the construct identification with the green hotel. In the second case, the mediator of the influence of green hotel attributes on attitude toward green hotels, intention to stay at green hotels, and willingness to pay a premium is the construct trust toward green hotels. Furthermore, controlling for social norms, personal norms strengthen the effects of green hotel attributes on both mediators. Analogously, controlling for personal norms, social norms strengthen the effects of those attributes on identification with the green hotel and trust toward green hotels. The results confirmed the existence of all the relations except the positive interaction effects between social norms and green hotel attributes on identification with the green hotel and trust toward green hotels.

When it comes to methodological issues regarding TPB implementation, a configurational model can be proposed as an alternative for the extension, decomposition, and merging of that theoretical approach [25]. The research considers the influence of attitude, subjective norm, and perceived behavioral control (predictors X) in formulating the behavioral intentions of green hotel guests'—continued use and recommendations (outcomes Y) by symmetrical model and asymmetrical model. That was performed in a manner that "the assumption in symmetrical thinking is that high or low scores of predictor (X) link with high or low scores of outcome (Y), whereas in an asymmetrical relationship, high/low scores of X do not necessarily connect with those of Y." The results of symmetrical model (SEM – structural equation modelling) showed all independent variables to be significant predictors of continued use, while only attitude and subjective norm in the case of recommendations. The results of the asymmetrical model for high scores on continued intention to use green hotels and recommend them are similar. Two propositions were given regarding those outcomes. Firstly, the positive attitudes towards the behavior are sufficient for achieving those goals. Secondly, there can be used a combination of high level of perceived behavioral control and low level of subjective norms. For low scores on continued intention to use green hotels, two combinations can be defined: firstly, low perceived behavioral control and high attitude towards the behavior, and secondly, low levels of attitude towards the behavior, and subjective norms, and high level of perceived behavioral control. For low scores on intention to recommend, there can also be defined two combinations: firstly, low level of attitude towards the behavior, and secondly, low levels of subjective norms, and perceived behavioral control. Finally, the results of the necessary condition analyses indicated that, without an attitude, intention to continue using as well as to recommend green hotels cannot be accomplished.

In certain studies, in which a configurational model was applied, tourists' behavioral intentions were analyzed in the context of, among others, demographic characteristics. Thus, demographic variables were used in combinations with host and accommodation place attributes in order to describe disabled tourists' behavioral outcomes in relation to p2p accommodations [37]. They were also included in an asymmetrical analysis related to the recommendation intention of canal boat tour participants [38], as well as in a configurational model developed for "predicting residents' support for tourism development (RSTD)" [39].

Although the TPB model was often used when analyzing customers' pro-environmental intentions and behavior, one of the model's shortcomings is related to "its relatively static perspective on behavior change" [24] (p. 213). Bearing in mind that behavioral change can be best seen as "a person's transition through a temporally ordered sequence of qualitatively different stages" [40] (p. 69), the understanding of customer behavior can be improved by implementing the dynamic approach in the model [24]. Thus, four different phases, each with a specific task, can be distinguished [40]: pre-decisional (turning certain wishes into obliging goals), pre-actional (forming a behavioral intention), actional (the implementation of intention) and post-actional (maintenance of new behavior).

TPB is implemented in the context of the dynamic approach for understanding moving into energy-efficient homes [24]. The main foundation of the approach used within that research is the difference of influences of different elements of TPB (hereby, they consider attitudes, social norms, perceived behavioral control, personal norms, and emotions as well) depending on the phase in the change of the behavior (pre-decision, pre-action, action) in which the respondent is.

Having all previously stated in mind, and especially that, according to the authors' knowledge, the dynamic approach was not previously implemented regarding green hotel choice, the following model is formulated—Figure 1.

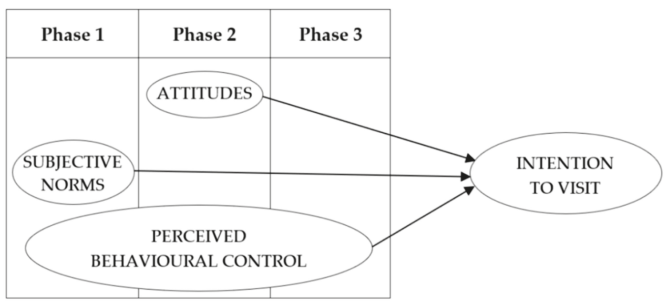

Figure 1. Conceptual model.

Within this research, the following hypotheses are set:

H1. *Intention to visit a green rural hotel is in the first phase of tourists' behavioral change (pre-decision) influenced by subjective norms and perceived behavioral control.*

H2. *Intention to visit a green rural hotel is in the second phase of tourists' behavioral change (pre-action) influenced by attitudes and perceived behavioral control.*

H3. *Intention to visit a green rural hotel is in the third phase of tourists' behavioral change (action) influenced by perceived behavioral control.*

H4. *Together with the increase in the phase of tourists' behavioral change, increases the influence of perceived behavioral control on intention to visit a green rural hotel.*

3. Materials and Methods

The questionnaire consisted of three parts. The first part was related to sociodemographic characteristics of respondents: gender, age, education, and marital status. The second part of the questionnaire was referring to identifying the phase in behavior change. It was performed by adapting formulations from previous research [24] to the topic of this research. Hereby, the respondents were offered to choose one of the following options: "So far, I've never thought about staying at a rural green hotel when traveling," "I have considered staying at a rural green hotel when traveling. However, I haven't put this plan into practice yet," "For my last travel I have stayed at a rural green hotel. It is my firm intention to do this in the future," or "For me it is a given to stay at a rural green hotel when traveling." According to the choice of one of the selected options, respondents were segmented into four phases of behavior change: pre-decision, pre-action, action, and post-action phase, respectively. The third part of the questionnaire was related to measuring variables from TPB (on a five-point Likert scale). That was performed by adapting items from previous research [32].

Personal communication with respondents from the Republic of Serbia was performed. The convenience sampling method was implemented. In order to try to interview the average user of tourist services, the respondents were approached at several of the largest Serbian towns near famous shopping centers during all seven days of one week. The precondition for a person to become a respondent was that he/she was using hotel services during 12 months before the interview. The questionnaire was either read to the respondent and he/she provided answers to the interviewer, or the respondent personally filled in the questionnaire in the presence of the interviewer. The questionnaires with no answer regarding phase in behavior change, or on more than one item referring to latent variables from TPB (43 in total), were excluded. In the case of missing only one item for some of the variables from TPB, it was filled in by a mean of other items belonging to the same latent variable. Data were processed in 2019. It included analysis of 289 answers.

The sample consisted of 48.8% males and 51.2% females. Hereby, the average respondent was 37.05 years old (standard deviation 10.21). When it comes to education, 45.3% of the respondents had finished secondary school, 7.6% of the respondents were students, and 47.1% had finished college or faculty. As for marital status, 63.3% of the respondents were married and 36.7% were single. Furthermore, 23.5% of the respondents were in the first, 41.9% in the second, 27.7% in the third, and 6.9% in the fourth phase of behavior change.

When analyzing the influences of TPB elements on intention to visit green rural hotels in different phases, multigroup structural equation modelling was performed. Hereby, the respondents in one of the first three phases were taken into account—as in [24]. Prior to performing multigroup SEM, the questionnaire was tested.

4. Results

4.1. Testing the Questionnaire

As all four constructs from TPB are reflective, individual indicator reliability, internal consistency reliability, convergent validity, and discriminant validity were examined [41]. For analyzing indicator reliability, standardized loading for each indicator was checked. As expected, they were higher than 0.7 (Table 1).

Table 1. Quality criteria of the reflective constructs.

ATTRIBUTES	Loadings	AVE	CR
ATTITUDES		0.688	0.898
For me, staying at a rural green hotel when traveling is good.	0.751		
For me, staying at a rural green hotel when traveling is desirable.	0.880		
For me, staying at a rural green hotel when traveling is pleasant.	0.861		
For me, staying at a rural green hotel when traveling is ethical.	0.820		
SUBJECTIVE NORMS		0.783	0.915
Most people who are important to me think I should stay at a rural green hotel when traveling.	0.921		
Most people who are important to me would want me to stay at a rural green hotel when traveling.	0.921		
People whose opinions I value would prefer that I stay at a rural green hotel when traveling.	0.809		
PERCEIVED BEHAVIOURAL CONTROL		0.842	0.941
Whether or not I stay at a rural green hotel when traveling is completely up to me.	0.917		
I am confident that, if I want, I can stay at a rural green hotel when traveling.	0.915		
I have resources, time, and opportunities to stay at a rural green hotel when traveling.	0.920		
INTENTION TO VISIT		0.774	0.911
I am willing to stay at a rural green hotel when traveling.	0.837		
I plan to stay at a rural green hotel when traveling.	0.892		
I will make an effort to stay at a rural green hotel when traveling.	0.909		

Satisfactory levels were obtained in the case of internal consistency reliability and convergent validity, as well. Hereby, the values of CR (composite reliability) and AVE (average variance extracted) were above 0.7 and 0.5, respectively [42,43].

For assessing discriminant validity, the Fornell–Larcker criterion was applied (Table 2).

Table 2. Discriminant validity assessment: Fornell–Larcker criterion.

	Attitudes	Subjective Norms	Perceived Behavioral Control	Intention to Visit
Attitudes	**0.829**			
Subjective norms	0.121	**0.885**		
Perceived behavioral control	0.481	0.053	**0.917**	
Intention to visit	0.474	0.242	0.426	**0.880**

Hereby, each construct's square root of AVE is higher than its correlations with other constructs [41], which confirms discriminant validity.

Having in mind that all variance inflation factor (VIF) values for all latent variables are lower than 3.3, "the model can be considered free of common method bias" [44] (p. 7).

4.2. Testing the Hypotheses

The effects of independent variables on Intention to visit green rural hotel have been analyzed by using PLS-SEM path coefficients. Table 3 presents their values for the entire model and for each of three phases as well. Furthermore, the R^2 value equaled 0.311.

Table 3. Path coefficients.

	Intention to Visit			
	Phase 1	**Phase 2**	**Phase 3**	**General**
Attitudes	0.080	0.643 *	−0.006	0.327 *
Subjective norms	0.787 *	0.152	−0.041	0.189 *
Perceived behavioral control	0.098	−0.011	0.891 *	0.259 *
* p < 0.05				

At the level of the entire model, significant positive effects have been recorded for all three independent constructs, attitudes, subjective norms, and perceived behavioral control (0.327, 0.189, and 0.259, respectively). When it comes to phases, attitudes construct had a significant positive effect only in the second phase (0.643), subjective norms in the first (0.787) and perceived behavioral control in the third phase (0.891). Differences in path coefficients between phases have been tested by the implementation of Multi-group Analysis (MGA)—Table 4.

Table 4. Multi-group analysis (MGA)—coefficients differences.

	Intention to Visit		
	| Phase1–Phase2 |	**| Phase1–Phase3 |**	**| Phase2–Phase3 |**
Attitudes	0.563 *	0.086	0.649 *
Subjective norms	0.635 *	0.828 *	0.193
Perceived behavioral control	0.109	0.793 *	0.902 *
* p < 0.05 or p > 0.95			

Hereby, in relation to attitudes construct, the path coefficient in phase 2 is significantly higher than coefficients in phases 1 and 3. In the case of subjective norms, the coefficient in phase 1 is significantly higher than coefficients in phases 2 and 3. Finally, in relation to perceived behavioral control, the path coefficient in phase 3 is significantly higher than coefficients in phases 1 and 2.

5. Discussion and Conclusions

From the research conducted within this paper, important implications can be derived for both theory and practice. When it comes to the theoretical contribution, it should be stressed that, according to the authors' knowledge, this research is the first dynamic approach to TPB in the context of green rural hotels. That presents the key contribution of this paper. The special significance of the topic is that it belongs to one of the two identified methodological issues regarding the TPB in recent studies—dynamic approach and asymmetrical modelling.

The results show that when the model is performed for all the respondents, the influence of each of the independent variables (attitudes, subjective norms, perceived behavioral control) on dependent variables is statistically significant. That is in accordance with almost all previous researches that implement SEM in general. Moderation analysis is rarely present [20,36] or fails to provide significant differences in those researches [20]. However, when moderation analysis is performed within this research, based on the phase in behavior change (pre-decision, pre-action, action), it can be concluded that the significant influence of all the variables is not present in each of the phases. In the first phase, there is a significant influence of only subjective norms on intention to visit green rural hotels; in the second phase, solely attitudes significantly affect the dependent variable; while in the third phase, perceived behavioral control is the only significant predictor of green rural hotels choice.

In the previous context can be discussed the confirmation of hypotheses. It should be noted that the first hypothesis is partially confirmed since intention to visit a green rural hotel is in the first phase of tourists' behavioral change (pre-decision), influenced by subjective norms, but not by perceived behavioral control. A similar situation can be observed regarding the second hypothesis, as well. Hereby, intention to visit a green rural hotel is in the second phase of tourists' behavioral change (pre-action), influenced by attitudes, but it is not affected by perceived behavioral control. The third hypothesis is confirmed since intention to visit a green rural hotel is in the third phase of tourists' behavioral change (action), influenced by perceived behavioral control. The fourth hypothesis is partially confirmed. When comparing the third phase of behavior change to previous phases, the influence of perceived behavioral control on intention to visit a green rural hotel is the strongest and statistically significant. However, in previous phases, influences of that variable are neither statistically significant, nor is there an increase in the second phase in comparison to the first.

The difference from the expectations regarding influence of independent variables is noticed in previous research as well [24]. From the results of this research, it can be concluded that, when a person has never thought to stay at a rural green hotel when traveling, the greatest influence on intention to visit such a hotel is the perception of opinion of people who are considered important. Furthermore, for people who have considered staying at a rural green hotel when traveling, but have not put that plan into practice yet, the greatest influence is the one of their own attitudes. Finally, for respondents that are already in the phase of action, the only importance is the perception of their own ability to perform such behavior. It was hypothesized that such influence would be important in previous phases as well, but the results did not support it. Two explanations can be given regarding such results. Firstly, because of the underdeveloped offer of such hotels in domestic conditions, that factor might become important to respondents only when they face the actual visit to them. Within the research, the questions were formulated in general, so it cannot be examined whether respondents in the action phase are referring to the domestic offer of green rural hotels or from such hotels abroad. Furthermore, the decision regarding visiting hotels is usually made much faster than, for example, the decision to buy a hybrid vehicle or to move into an energy-efficient home. That can be an additional explanation why the perception of own ability to perform a behavior does not become important before the action phase.

The practical recommendations can be given for different segments obtained in this research based on the phase in behavior change. All these recommendations can be of special importance to sustainability; as it is proven within the paper, the significance of rural tourism and green hotels in that context. For people who have never thought to stay at a rural green hotel when traveling, influencing persons can be relied on. Additional research is necessary to discover persons who might be considered as relevant for a great part of respondents from that segment and, if using massive communication, it might be chosen to cooperate with some of the celebrities. Hereby, attention should be dedicated to those people who like to travel and act socially responsible. They can be engaged in promotional campaigns, in which the emphasis should be on rural areas and their natural beauties. For this purpose, social networks, especially Instagram, could be of great help. For the segment of respondents who have considered staying at a rural green hotel when traveling, but have not put that plan into practice yet, it is of the greatest importance to influence their positive beliefs about performing such actions as well as their evaluations. A campaign containing information that would help in accomplishing that goal would be recommendable. Thus, it may include some information related to advantages of rural areas, such as natural and healthy environment, less noise, clean air, and domestic food. Besides presenting the countryside as a place for rest and relaxation, attention should be dedicated to the ethical aspect as well. Hereby, potential tourists should be informed about the sustainability concept, i.e., environmental protection and all benefits for the social community in rural areas. When considering the segment of respondents in the action phase, it is important to increase their perception of their ability to stay at green rural hotels. In addition to their consideration of the resources and time needed to visit rural green hotels, support should also be provided to the supply side of the market. Hereby, it would be useful to provide them with information about offers of such hotels in domestic conditions, about the best routes to approach them, and the necessary time and costs when performing such actions. For example, popular TV shows presenting routes to popular destinations for summer vacations could also be used to transmit previously listed information.

Future researches could use larger and more representative samples. Additional moderations considering whether the destination is domestic or foreign can be included. Rural tourism offer can be considered without focusing only on green hotels. Finally, asymmetrical modelling could be implemented on the data of this research as well, in order to obtain an even deeper understanding of TPB functioning. Beside elements of TPB, that analysis could also integrate demographic data.

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sustainability

Article

Dynamic Optimization of Fuel and Logistics Costs as a Tool in Pursuing Economic Sustainability of a Farm

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Abstract: Improving the performance and economic sustainability of agricultural producers requires the integration of many dimensions, one of which is logistics. Establishing efficient and cost-effective transportation is a key element of establishing sustainable linkages along food supply chains between farmers, storage and transport companies, and consumers. In this regard, infrastructural constraints to sustainability in agricultural production exacerbate transportation costs and risks, and thus result in lower performance of agricultural producers. As fuel consumption is, first, the most significant cost in agricultural logistics and, second, particularly sensitive to disruptions of transport, loading, and storage infrastructure, management of fuel costs is crucial to assure profit margin of an agricultural enterprise. By transforming the standard economic order quantity (EOQ) model, the authors attempt to build an approach to the optimization of fuel costs. The analysis made in the cases of twelve large crop farms in three territories of Southern Russia allowed the consideration of: (1) fragmentation in storage infrastructure; (2) variations in fuel consumption depending on the vehicle load ratio; (3) the use of their own fleet of vehicles against the outsourcing of transport operations. The authors find that the tactics of optimization of fuel costs vary depending on the location of a farm in relation to grain storage facilities. Particularly, the farms located in areas of high concentration of storage facilities benefit from using their own fleet of vehicles, while those experiencing longer distances of transportation should outsource the performance of logistics operations to third parties. To overcome a site-specific nature, the transformed EOQ model should accommodate country-specific requirements, specifically, the level of fragmentation of transport and storage infrastructure, average distance of transportation from a farm to receival site, and average fuel consumption rates depending on the types of trucks commonly used by farmers. The key recommendation is that sustainability-aimed management of logistics costs should consider combining the operation of trucks by a farm with the outsourcing of transportation operations to address the fragmentation of transport and storage infrastructure.

Keywords: agriculture; cost; dynamic optimization; fuel; logistics; transportation

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1. Introduction

Logistics costs often represent a large portion of total supply chain costs [1], which is why cost reduction has always been one of the major performance objectives in logistics management [2–4]. Total logistic costs reveal much about the locational dynamics of logistics activities, particularly distribution centers, since they indicate the weight of the most important factors [5].

The methods for determining logistics costs vary depending on many parameters, including the type of industry, main components of logistics activities, and cost-accounting or macro context [6,7]. There have been several levels suggested on which the components of logistics costs can be broken down. Sople [8] identified three cost components, transportation, storage, and inventories, while Rushton et al. [9] added administration costs to those three. Ayers [10] identified five components of logistics costs: purchased materials and the associated labor, transportation, warehousing, inventories, and packaging. Lambert et al. [11] and Zeng and Rossetti [12] ended up with another set of five key logistics cost elements: transportation, warehousing, order processing/customer service, administration, and inventory holding.

One of the most common ways to systemize logistics costs is to place them along the dimensions of direct, indirect, overhead, and function-related costs (Table 1).

Table 1. Logistics costs dimensions.

Direct/Indirect Costs	Function-Related/Overhead	
	Function Related	Overhead
Direct cost	Transportation costs Cargo handling Warehousing Custom clearance Documentation costs	Inventory carrying Value of time Operation costs
Indirect costs	Packaging costs, including material Costs of logistics equipment, premises, and capital Administration costs Costs related to logistics supporting functions	Costs of lost sales Costs of customer service level Costs of non-marketable goods Trade-off costs

Source: authors' development based on [13].

In the majority of the studies, transportation costs remained the dominant consideration, as they account for about half of the logistic costs internationally [14]. In common costing terminology in transport, direct costs are those directly attributed to a vehicle (fuel, insurance, road license), while indirect ones are general costs that result from running a business, referred to as overhead, administrative, or establishment costs, and are spread equally amongst the vehicles in use [9]. Alongside this common breakout, transport costs are broken down into three types: standing, running, and overhead (the first two classified as direct costs, the latter one borne by the whole fleet of vehicles) (Table 2).

Table 2. Types of transportation costs.

Types	Elements	Costs
Standing (fixed)	Original purchase cost of a vehicle	Depreciation (either straight-line or reducing balance method)
	Tax and licenses	Vehicle exercise duties, operator's license, driver's license, travel charge
	Vehicle insurance	Amount varies depending on the area of operation, number of vehicles in the fleet, types of the load carried, etc.
	Drivers' costs	Drivers' wages, pensions, holiday pays, and allowances made for national funds and budgets
	Interest on capital	Interest repayable on a loan used to purchase a vehicle, or interest that is lost because the money is used to purchase a vehicle and therefore cannot be invested elsewhere
Running (variable)	Fuel	Cost of fuel per kilometer
	Oils and lubricants	Cost of engine oils and vehicle lubricants per kilometer
	Tire wear	Cost of tire usage linked to the distance the vehicle travels
	Drivers' overtime	Costs associated with drivers, e.g., drivers' overtime, bonus, and subsistence costs
	Repairs and maintenance	Cost of repair and maintenance (labor, spare parts, and workshop) related to distance after which the vehicles should be regularly maintained
Overhead	Fleet overheads	Costs of all the reserve equipment and labor required to run an efficient fleet of vehicles
	Transport department overheads	Charges and costs that are clearly concerned with the transport department but cannot be directly related to any one vehicle
	Company administrative overheads	Costs that are central to the running of a business and that have to be apportioned between all the different company departments

Source: authors' development based on [9].

Transportation has one of the most critical impacts on the performance efficiency of an organization [15], since the availability of road infrastructure and transport services increases mobility and encourages production [16]. El Bouzekri et al. [17] recognized transportation as an irreplaceable part of the supply chain, through which economic development was possible. Rantasila and Ojala [13] and Gonzalez et al. [18] also identified transportation costs as one of the major drivers affecting the competitiveness of a firm. While the development of transport systems affects production and logistics in a positive way, it also introduces additional challenges to many sectors because it increases the load on transport networks, reliability problems, and the capacity of existing transport infrastructure to accommodate higher flow rates and translate them to the reduced per unit costs. The management of logistics costs is particularly relevant in agriculture, where distribution infrastructure is not well developed and often partial [19]. High logistics cost is one of the major factors that hinders agricultural producers, particularly small and medium ones, from being competitive in the market [20]. Bosona [21] indicated that transportation and other costs, such as inventory, warehousing, and administration costs, could significantly constrain the competitiveness of food producers. In rural areas, high transportation costs and risks are exacerbated by poor local level roads and inefficient transport infrastructure network and services, which, taken together, result in a low level of coordination between agricultural producers and market failures [22].

The cost of fuel is normally the largest of all the transportation costs [9,23]. Fuel is a particularly significant cost in agriculture due to two major reasons. First, the fuel consumption of specialized agricultural machinery and transport vehicles is higher compared to average commercial vehicles. Second, agricultural enterprises have to establish and keep substantial reserves of fuel during winter due to seasonality in agricultural activities. Third, fuel costs are more vulnerable compared to other types of costs because of the constant rise in energy costs due to the shortages in the season of high demand (spring–autumn) [24]. Reduction of fuel costs contributes the most to the increase in the profit margin of agricultural enterprises [25], reduction of per unit costs of commodities with high fixed costs [26], enlargement of the market areas [27], and thus allows for a larger number of agricultural producers to specialize and localize. The concentration of farms, food industries, and wholesalers into a smaller number with large sizes is the main characteristic describing the current trend in the agricultural sector in many countries [21,28]. Even in land-abundant countries, large farms are emerging, in part, as a response to the market and infrastructural, including logistics, deficiencies faced by agricultural producers [29]. For instance, in Russia, the concentration of agricultural producers and greater specialization in output across districts have been common features of agricultural recovery during the 2000–2010s [30]. There are 76,000 growers in Russia producing over 107 mmt of crops annually, but the majority of them are in the southern and central parts of the country. Large-scale farms account for 75% of production [31]. Over recent years, Russia has restructured its key infrastructural bottlenecks, but still experiences logistics problems [32]. On-farm storage capacity is only 45–50% of an average harvest. Crop producers, therefore, use off-farm storage facilities, many of which are outdated, of low storage capacity, and unevenly distributed across the country. Logistics costs thus escalate due to the long distances of transportation and underdeveloped transport and storage infrastructure. Both size and vertical integration help agricultural producers to respond to market and infrastructural imperfections [33], but in the situation of fragmented distribution, the share of the transportation cost per unit of the product have increased.

The management of fuel costs in food supply chains has received more and more attention due to many reasons, including increasing transportation between production facilities, the roles and the types of operations performed in facilities, capacities allocated to each facility, markets that facilities will serve and sources that will feed facilities [34], traceability of food quality and the potential market for local food producers [35], and the increasing consumption of fuel and the associated environmental impact [21]. There is, however, a major challenge most frequently mentioned in the results of the existing studies in the field of fuel costs management in agriculture: the research methods are not unified are fuel cost components are not sufficiently standardized, thus the results are not comparable. Additional challenges include difficulties related to collecting transparent information about the complexity of logistics activities and calculating the costs with due account to a variety of fuel consumption rates of different types of machinery involved in the transportation. The existing methodologies for evaluating logistics costs in agriculture are sparse due to the variety of cost items involved and the complexity of relationships within the logistics system. As more agricultural organizations are outsourcing their transportation activities to specialized companies, it becomes increasingly critical to understand and evaluate logistics costs associated with transportation and fuel in order to assure the profit margin. In view of the lack of inventory in previously conducted studies on logistics costs in agriculture, the purpose of this paper is to develop a reliable method of optimization of total logistics costs by means of fuel costs and thus provide an approach for evaluating and monitoring the logistics performance of an agricultural organization and establish its economic sustainability.

2. Materials and Methods

In the optimization of fuel costs, the variability of the fuel–logistics costs model is preconditioned by three factors: (1) the volatility of fuel prices; (2) dynamic changes in the cost of logistics outsourcing (transportation from supplier to agricultural enterprise); (3) fuel consumption by agricultural enterprises in different stages of the production cycle [36]. In many studies, the complexity of interrelations between the dynamic factors has been addressed by the adoption of the economic order quantity (EOQ) model for the assessment of fuel and logistics costs. One of the first attempts to consider a tradeoff between fixed ordering cost and inventory carrying cost was made by Harris [37], whose deterministic inventory planning model laid the foundation for various kinds of extensions of mathematical modeling to guide managers in making business decisions [38]. Harris' model was further generalized by Wilson [39], who derived the formula to obtain the economic order quantity. The standard EOQ model assumes that demand is constant, and that inventory is depleted at a fixed rate until it reaches zero [40] (Equation (1)):

$$V = \sqrt{\frac{2 \times C_c \times C_f}{C_s}}, \tag{1}$$

where V = volume of fuel required for continuing operation of a farm, L; C_c = consignment cost/fuel, $; C_f = fuel consumption of a farm, L; C_s = storage cost/fuel, $.

The model is considered an appropriate tool for calculating the reorder point and the optimal reorder quantity to ensure the instantaneous replenishment of inventory with no shortages [40]. Khan et al. [41], Rao and Bahari-Kashani [42], Huang et al. [43], and Pentico and Drake [44] regarded the EOQ model as a valuable tool for managers who make decisions about how much inventory to keep on hand to incur the lowest possible costs.

Based on the initial assumptions made by Harris [37], further research on the EOQ has evolved in three major directions: logistics, lot-sizing rules, and extensions.

Substantiating the application of the EOQ model in transportation and logistics, Ghasemi and Nadjafi [45] determined the optimum total costs, economic ordering quantity, and related optimum quantity to the ordering cycle length. Keskin et al. [46] used the EOQ model to optimize total logistics costs, including transportation, inventory replenishment, and storage costs. In agricultural logistics, employment of the model allows a decision to be made on the gross volume of fuel C_f required for continuing agricultural production and operation of a farm (Equation (2)):

$$C_f = D \times \frac{FCR}{100} \times N \times T, \tag{2}$$

where C_f = fuel consumption in a farm, L; D = total distance per vehicle, km; FCR = fuel consumption rate, L per 100 km; N = cargo vehicles operated by a farm during a year, number of vehicles; T = trips per vehicle, number of trips.

A series of studies investigated the performance of the EOQ model against the quantity of an item ordered for delivery, or lot size. Evan [47] was among the first who demonstrated a significant relationship between lot size and the quality of a product, while Melnyk and Piper [48] examined the effects of lead time errors on logistics performance and efficiency.

The variety of extensions of the EOQ model includes, among others, the development of cost elements of the standard EOQ model by detaching the capital cost as a determinant factor [49], application to retail cycle stock inventories [50], inclusion of storage size considerations [42], and the integration of product pricing and order sizing decisions [51]. A number of studies have explored the extension of the EOQ model in agriculture. Commonly, in agricultural logistics, the rationale of employing the EOQ model is that it provides a good indication of whether or not the parameters of the agricultural logistics chain are reasonable, even if varied dynamic factors do not hold exactly. Hu et al. [52] complemented the EOQ model by multiple cycles' theory to address decreasing characteristics of agricultural products. Arskiy [36,53] explored the efficiency of the use of the EOQ model in logistical costs calculations in small farms. Chen et al. [54] provided a method to determine the optimal replenishment policy of integrated agricultural supply chains with stochastic demand based on the EOQ and EPQ (Economic Production Quantity) models. Most of the studies above, however, resulted in a finding that the use of the standard model in multiunit and multimodal supply chains encountered challenges and difficulties. Since the standard EOQ model deals with gross consumption of fuel per particular distance of transportation, it thus does not allow the consideration of the variations between the modes of transportation (loaded or empty trip) or the modes of storage (trips between enterprise's storage facilities, outsourcer's warehouse, fuel and grain hubs). Depending on who executes the storage, C_s may be calculated in different ways. In the case of an agricultural organization storing the fuel on its premises, C_s is the maintenance cost, which includes the operation and repair of fuel tanks, depreciation charges, property tax, insurance premium, electricity, and water. In a case where the storage is outsourced, C_s simplifies to the cost of the warehouse lease or custody contract [53]. Similar to C_s, consignment cost C_c is determined in various manners depending on the organization which performs transportation. When performed by an agricultural organization itself, the delivery of the agricultural product or fuel is associated with the cost of operation and maintenance of trucks, their depreciation, cost of fuel consumed during transportation, transport tax, and insurance, among other expenditures. When delivery is outsourced, C_c is a price an agricultural organization pays to its contractor [55].

Irrespective of the particular mode of storage and delivery, fuel consumption rate is a major parameter which affects both storage and consignment costs [56]. Notably, despite the clear practical importance of the influence of fuel consumption on management decisions in agricultural logistics, this parameter has been rarely adopted by the EOQ models in the previous literature. Therefore, the authors seek to bridge this gap by finding an appropriate value of C_f crucial for the optimization of logistics costs of both the storage of a particular volume (required marginal reserve) of fuel and cost efficiency of available financial resources. Chen et al. [54] and Tebekin [57] reported the implementation of the EOQ model as promising in large agricultural enterprises where logistics planning was based on the system analysis of external and internal environments and the application of corrections in accordance with the influence of dynamic factors. Accordingly, this study involved twelve large agricultural enterprises located in three territories of Southern Russia, namely, Stavropol, Krasnodar, and Rostov. Rada et al. [30] reported the southern district of Russia as the leading region of Russia's agricultural revival, where producers appeared to have exploited climatic, infrastructural, and institutional comparative advantages over other districts. The rationale of the choice is that, first, southern parts of Russia are the major producers of agricultural commodities (the three regions taken together provide 16.6% of the gross domestic agricultural production of the country, including 22.0% of the overall national production of crops [58]), second, the agricultural sector is dominated by large enterprises (over 20,000 hectares in size), many of which descended from giant ex-Soviet collective farms [59]. The study included agricultural enterprises specialized in crop production, particularly winter wheat, sunflower, and corn as major crops produced in the South of Russia. The rationale of focusing on crop farms is that they do not commonly establish their own storage facilities to keep agricultural crops but use large grain elevators instead. In the meantime, in the South of Russia, agricultural logistics infrastructure is underdeveloped and fragmented, many of the grain storage facilities are outdated and of low capacity. Therefore, large crop farms are bound to use transportation intensively to maintain regular traffic between fields, temporary storage facilities, grain elevators, and distribution hubs.

To reflect the country-specific fragmentation of transport and storage infrastructure, in this study, the standard EOQ model accommodated the following transformations:

Transformation 1. Many authors, including Saha et al. [60], Lin and Chung [61], and Gerami and Shidlovskiy [62], formulated the EOQ model by considering two facilities (particularly warehouses): the one owned by the organization and the other one rented. Eksler et al. [63] introduced a dependency factor to reflect a correlation between two products transported, stored, and distributed by a firm simultaneously. Drezner et al. [64] presented the model with two substitute products and found that only partial substitution or no substitution might be optimal due to the non-linearity of the decision variables in the total cost expression. Differentiation between delivery points, however, has been less considered. The authors' transformation of the standard EOQ model thus accommodated the differentiation between transportation to/from farm's field storage facilities and/or outside warehouse, contractor's storage, and intermediate fuel or grain hubs to reflect the variations in the distribution of costs depending on who performs storage and transportation.

Transformation 2. Few extensions of the standard model have addressed a differentiation between loaded and empty trips. Ben-Chaim et al. [65] proposed a model in which vehicle fuel consumption was separated into cruising at constant speed and acceleration, but did not take into account fuel consumption during idle mode. Ramirez et al. [66] analyzed fuel consumption behavior with several options of performance metrics, including gross weight of transportation and empty vehicle weight, but did not validate the variability of loads. To reflect the variations in fuel consumption depending on the vehicle load ratio, the authors' variant of the model estimated differentiations between (1) distances between the farm, receival site, and fuel distribution point and (2) fuel consumption rates in loaded and empty trips (Equation (3)):

$$C_f = \left(D_1 \times \frac{FCR_l}{100} + D_2 \times \frac{FCR_e}{100} \right) \times N \times T + R, \quad (3)$$

where C_f = fuel consumption in a farm, L; D_1 = distance between farm and receival site, km; D_2 = distance between receival site, fuel distribution point, and farm, km; FCR_l = fuel consumption rate/loaded trip, L per 100 km; FCR_e = fuel consumption rate/empty trip, L per 100 km; N = cargo vehicles operated by a farm during a year, number of vehicles; T = trips per vehicle, number of trips; R = fuel reserve, L.

Transformation 3. In earlier studies, Zoldy and Zsombok [67], Nkakini et al. [68], Zhou and Jin [69], and Huertas et al. [70] attempted to incorporate various external and internal parameters, including vehicle driven, road related, usage related, and ambient parameters, that could have predictive effect on fuel consumption and refueling of the vehicle. To the best of the authors' knowledge, none of the studies have employed the EOQ model to measure the variations in fuel consumption, while the models which were used in the abovementioned studies cannot provide satisfactory predictions for vehicles operating under the conditions of underdeveloped and disrupted logistics chains. To respond to irregular logistics risks (fuel overrun, increase in consumption rate due to heavy road traffic, etc.), the authors complemented the standard EOQ model with fuel reserve provisioning.

Standard (Equation (4)) and transformed (Equation (5)) models were applied consecutively to agricultural enterprises under study to reveal the deviation of the actual volume of fuel reserve maintained in 2013–2017 (V_s) from the optimal one (V_t):

$$V_s = \sqrt{\frac{2 \times C_c \times D \times \frac{FCR}{100} \times N \times T}{C_s}}, \tag{4}$$

where V_s = volume of fuel required for continuous operation of a farm/standard approach, L; C_c = consignment cost/fuel, \$; D = total distance per vehicle, km; FCR = fuel consumption rate, L per 100 km; N = cargo vehicles operated by a farm during a year, number of vehicles; T = trips per vehicle, number of trips; C_s = storage cost/fuel, \$.

$$V_t = \sqrt{\frac{2 \times C_c \times \left(D_1 \times \frac{FCR_l}{100} + D_2 \times \frac{FCR_e}{100}\right) \times N \times T + R}{C_s}}, \tag{5}$$

where V_t = volume of fuel required for continuous operation of a farm/authors' approach, L; C_c = consignment cost/fuel, \$; D_1 = distance between farm and receival site, km; D_2 = distance between receival site, fuel distribution point, and farm, km; FCR_l = fuel consumption rate/loaded trip, L per 100 km; FCR_e = fuel consumption rate/empty trip, L per 100 km; N = cargo vehicles operated by a farm during a year, number of vehicles; T = trips per vehicle, number of trips; R = fuel reserve, L; C_s = storage cost/fuel, \$.

Taking into account the difficulty of obtaining the data from large agricultural enterprises in Russia, data collection was performed by one of the co-authors, A.A., during his in-person visits to each of the twelve sites. The visits were pre-agreed with and supervised by local administrations (ministries of agriculture, agriculture development divisions) in Krasnodar, Rostov, and Stavropol regions. During March–April 2019, A.A. interviewed the heads of the farms and logistics managers to learn about (1) the type of transportation operation (own or outsourced fleet), (2) geography of trips (between farm premises, receival cites, and fuel distribution points), (3) the types of cargo vehicles used, (4) number of trips per vehicle, (5) fuel reserve volumes, and (6) storage costs. To make V_t estimations comparable between the farms and territories, average parameters of FCR_l and FCR_e were used (32.0 L per 100 km and 27.4 L per 100 km, respectively) as those pertaining to a common type of trucks (KAMAZ 65115) used for transportation of grain and bulked cargo in Russia. Based on the earlier findings of Arskiy [36,56], R was taken as 15% of the total volume of fuel consumption. In each of the three territories, grain storage facilities located within the distance of 60 km from the farms were identified, as 30–60 km is the average distance from farm to receival site reported for Russia by Australian Export Grains Innovation Centre [31].

3. Results

Krasnodar region (Figure 1) is the one with the most developed agricultural infrastructure in Russia, including grain elevators. This study demonstrated that three out of four enterprises (Labinsky, Novokubanskoe, and Niva Kubani) normally transport grain within an area of 20–30 km to large-capacity elevators located in Labinsk, Armavir, and Bryukhovetskay. Labinsky and Novokubanskoe farms use their own transport vehicles while Niva Kubani outsources transportation. The Primorskoe farm stores grain at the elevators located in the districts other than Temryuksky within a range of 70–100 km (hubs in Slavyansk-na-Kubani, Krymsk, and Temryuk) and outsources transportation.

In the Rostov region, grain storage infrastructure is more fragmented compared to Krasnodar, as the majority of grain elevators are concentrated in the south around the main distribution and transport hubs of Rostov-on-Don and Aksay (Figure 2). Fragmentation provides competitive advantages to agricultural enterprises located in Aksaysky (Donskoy farm) and Egorlyksky (Zarya farm) districts in the forms of a shorter distance of transportation and more destination alternatives.

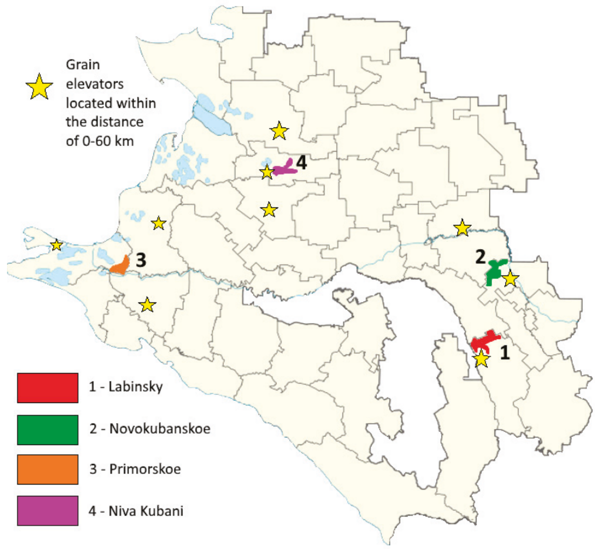

Figure 1. Krasnodar region: agricultural enterprises under study and grain elevators. Source: authors' development.

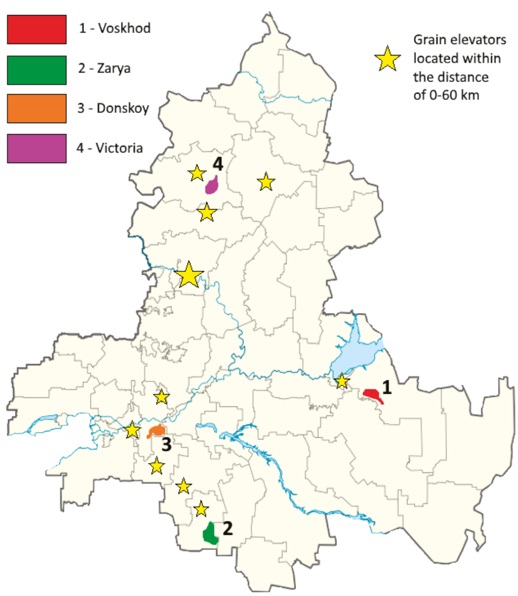

Figure 2. Rostov region: agricultural enterprises under study and grain elevators. Source: authors' development.

Agricultural commodities from Victoria farm are delivered to the district's only elevator in Millerovo. The closest multipurpose terminal elevator of large capacity is located in Kamensk-Shakhtinsky (approximately, 90 km from Victoria farm's internal storage facilities). The farm uses their own fleet of vehicles and thus has the biggest volume of fuel required for continuous operation among the enterprises under study.

Among the four enterprises of the Rostov region under study, the Voskhod farm has one of the longest delivery distances (83.1 km in 2013–2017) and outsources the major part of its cargo to transport companies. Within the area of 60 km, there is only one grain storage terminal in Volgodonsk whose capacity is insufficient to serve crop producers in the eastern part of the territory (Dubovsky, Zimovnikovsky, and Zavetinsky districts).

In the Stavropol region, large-scale crop production prevails in the north-western districts of Novoaleksandrovsk and Krasnogvardeysk, where the region's biggest agricultural enterprises are located (Rodina and Pobeda, respectively) (Figure 3). Storage infrastructure is not well-developed. Within the 30–60 km area around the four farms under study, there is a limited choice of grain elevators of low capacity. In addition to using local storage facilities, Rodina, Pobeda, and Voroshilova dispatch grain to the elevators in the neighboring Krasnodar region (cities of Armavir and Labinsk), which increases the distance of transportation to 80–100 km.

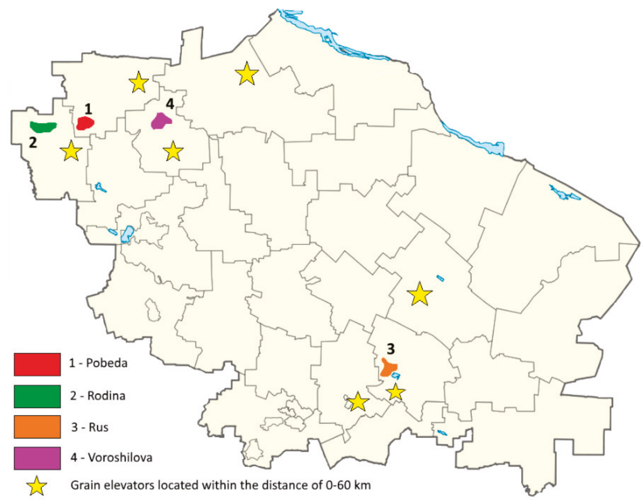

Figure 3. Stavropol region: agricultural enterprises under study and grain elevators. Source: authors' development.

For the farms located in the territories where storage facilities are concentrated (Labinsky, Novokubanskoye, and Niva Kubani in the Krasnodar region; Zarya and Donskoy in the Rostov region; Rus in the Stavropol region) the average actual expenditures of fuel are lower compared to those enterprises which dispatch crops for storage out of the average 30–60 km area (Primorskoye farm in the Krasnodar region; Victoria and Voskhod farms in the Rostov region; Pobeda and Rodina farms in the Stavropol region) (Table 3).

In all cases, the employment of a transformed approach makes it possible to decrease the volume of fuel required for continuous operation of a farm and thus optimize logistics expenditures. However, this is a very vague and relatively expected finding: the longer the distance of transportation the bigger the potential to save fuel by introducing dynamic optimization practices. Worthy of separate attention are the variations between V_s and V_t. The estimations vary substantially, from only 1.96% (Novokubanskoe farm) to almost 28.41% (Zarya farm) depending on the combination of two factors: (1) proximity to grain storage facilities of sufficient capacity (D_1); (2) use of own fleet of vehicles or outsourced transportation. The latter parameter directly affects the distance between the receival site, fuel distribution point, and the farm: the D_1–D_2 difference is lower in those farms which outsource transportation. In longer distances, the difference results in bigger cost-saving potential.

The study discovers that V_s–V_t gain is higher in the farms located farther from the elevators, provided, however, that they outsource storage and transportation operations to third parties (Table 4).

Table 3. Distance of transportation and volume of fuel required for the continuous operation of agricultural enterprises under study, average in 2013–2017.

Territory	Agricultural Enterprise	Transport	D_1 km	D_2 km	V_s L	V_t L
Krasnodar region	Labinsky	Own	10.4	4.2	7552	7186
	Novokubanskoe	Own	16.8	3.8	9081	8903
	Primorskoe	Outsource	67.2	10.7	6379	6088
	Niva Kubani	Outsource	12.5	18.6	8812	7275
Rostov region	Voskhod	Outsource	83.1	21.4	13,223	12,035
	Zarya	Outsource	22.3	12.6	5002	3581
	Donskoy	Own	9.4	2.4	4289	4016
	Victoria	Own	88.0	32.7	15,601	12,494
Stavropol region	Pobeda	Own	71.7	26.2	12,388	10,290
	Rodina	Outsource	67.6	14.5	10,997	10,689
	Rus	Outsource	25.1	13.8	6618	5391
	Voroshilova	Own	35.3	10.5	14,009	12,589

Source: authors' development.

Table 4. V_s–V_t variations depending on the distance and the mode of transportation: grouping of agricultural enterprises.

Groups	D_1	Transport Mode	Agricultural Enterprises/Territory	V_s–V_t Variation, Percentage
Group 1	0–60 km	Own	Labinsky/Krasnodar	4.85
			Novokubanskoe/Krasnodar	1.96
			Donskoy/Rostov	6.37
			Voroshilova/Stavropol	10.14
Group 2	0–60 km	Outsource	Niva Kubani/Krasnodar	17.44
			Zarya/Rostov	28.41
			Rus/Stavropol	18.54
Group 3	>60 km	Own	Victoria/Rostov	19.92
			Pobeda/Stavropol	16.94
Group 4	>60 km	Outsource	Primorskoe/Krasnodar	4.56
			Voskhod/Rostov	8.98
			Rodina/Stavropol	2.80

Source: authors' development.

Conversely, the farms located in the areas of high concentration of storage facilities and thus enjoy a shorter D_1 as a competitive advantage may benefit from using their own fleet of vehicles and saving fuel by optimizing transportation routes, number and workload of vehicles, and fuel reserve.

4. Discussion

In many previous studies, transportation has often been ignored as a source of competitive advantage [71]. In agriculture, where development is traditionally based on the exploitation of land resources, transportation has never been the major way to improve productivity or increase performance [72]. Recently, however, development of agriculture has been recognized as sensitive to the development of transport infrastructure and logistics networks. The findings of this study actually contribute to the mainstreaming of agricultural logistics in support of Platteau [73], Jacoby [74], Fan et al. [75], Mu and Van de Walle [76], and Gebresenbet and Bosona [19]. In all the territories under study, transportation and crop storage infrastructure is disintegrated, which supports earlier findings by Brewer et al. [77] and Saltmarsh and Wakeman [78] of the high fragmentation of distribution in food systems. Substantial parts of intra- and inter-field roads, particularly in the Stavropol region, are earthen, which means they can handle limited volume and loads. Using the existing road network for the transportation of heavy and bulky agricultural commodities (primarily wheat, sunflower, and corn) increases fuel consumption and thus neglects the cost optimization efforts of local agricultural producers. This finding correlates with Chakwizira et al. [22], who reported poor road infrastructure as the major threat to the successful implementation of development strategies in rural areas.

In this study, road infrastructure itself was not considered among the factors affecting fuel costs, but the overview of existing grain storage infrastructure nevertheless demonstrates that agricultural producers should minimize using their own vehicles when transporting crops longer distances. In furtherance of Ji et al. [79] and Lv et al. [80], we found that the rationale of outsourcing is delegating the risks of using the obsolete road, loading, and storage infrastructure to third parties and thus avoiding the expenditures which originate from the infrastructural inadequacy (higher fuel consumption, depreciation of fleet, repair, standby time). Parkhi et al. [25] agree that outsourcing makes an intermediary bear all the risks of poor infrastructure, vehicle breakdown, and road accidents.

The longer the distance of transportation the higher the risk probability and related expenditures, particularly when crop supply networks are underdeveloped and fragmented. An investigation of logistics processes based on the network management method made by Arskiy [3,24,53] demonstrated that due to inadequate infrastructure and consecutive loading and unloading operations, standby time might reach 50% of a vehicle operating time, thus increasing fuel losses. Gebresenbet and Ljungberg [81] also mentioned that during grain-related transport routes, unnecessary/unjustified motor idling was found to be more than 30% of stoppage time. Our results confirm both findings: higher losses of fuel are registered in those farms which transport crops outside of the 60 km zone by their own vehicles. Pursuing this practice, Victoria farm increased its fuel costs by 19.92%, and Pobeda farm by 16.94%. On the contrary, Primorskoe, Voskhod, and Rodina farms succeeded in reducing their fuel costs down to optimal values by outsourcing their transportation operations, which supports the conclusion of Picazo-Tadeo and Reig-Martinez [82] on the positive relationship between outsourcing and technique efficiency in agriculture.

Another rationale of outsourcing is the high seasonality of agricultural production. Farmers typically harvest and dispatch most of their crops in the three months from July to raise cash for the new season, repay loans, and avoid storage fees. Seasonality has a great effect on vehicle utilization efficiency in terms of the depreciation–output criteria. The intensity of delivery at the harvest season causes capacity problems for vehicle resources, along with the increased load on transport, loading, and storage infrastructure [19]. In the low season, on the contrary, about half of the vehicle capacity is unutilized, particularly in the farms which mostly run their own vehicles [83]. By outsourcing transportation and storage operations, farmers attempt to reduce non-manufacturing costs, which correlates with Parkhi et al. [25], who find that by means of outsourcing, agricultural enterprises optimize and depreciate capital costs.

In shorter distances, however, the effect of outsourcing is adverse: the inclusion of an intermediary to a supply chain increases fuel costs radically. Among the outsourcers, in Zarya, fuel costs deviated from the optimized level by 28.41%, in Rus by 18.54%, and in Niva Kubani by 17.44%. This result contradicts the findings of many authors, including Zhang et al. [84], Azadi et al. [85], and Zhang [86], who all made no allowance for the distance of transportation when advocating agricultural outsourcing. Instead of contracting with third parties, the farms where $D_1 < 60$ km should operate their own cargo vehicles and thus manage their fuel costs. Being located close to grain storage facilities, such farms avoid the disadvantage of fragmented storage networks. At the same time, shorter distances allow an increase in the utilization rate of a vehicle, reducing turnaround time, and thus neglecting the adverse effects of poor road infrastructure on fuel consumption and vehicle depreciation.

According to Picazo-Tadeo and Reig-Martinez [82], outsourcing in agriculture has traditionally been seen as a managerial strategy of smaller farms to achieve higher levels of efficiency. Igata et al. [87]

also concluded that contracting is used significantly more by smaller farms, while larger enterprises can maintain modern machinery to perform their transport operations. This study, however, demonstrates that outsourcing transportation allows agricultural producers to achieve efficiency regardless of their size. Large farms do not necessarily hold a fleet of vehicles to serve transportation but reduce the use of farms' own transport in their attainment of logistics efficiency. Such reduction leads towards the coordination and logistics networks integration and thus has a positive impact on agricultural producers by managing the number of vehicles to be deployed for crop transportation, thus optimizing the fuel and logistics expenditures of a farmer.

5. Conclusions

As efficient logistics emerges as a prerequisite for agricultural enterprises competing in today's market, understanding the cost-effectiveness of transportation has been drawing interest. In terms of reducing logistics costs, increasing the performance of crop producers, and improving access for agricultural outputs, the development of transport networks and improvement of transportation activities along food supply chains are essential.

This paper relied on a case study of twelve large agricultural enterprises in Russia as a basis to derive an evaluation framework for assessing the effectiveness of their logistics operations in the conditions of fragmented grain storage infrastructure. The authors extended the standard EOQ approach to measuring the annual fuel consumption of a farm and presented a way to optimize fuel costs based on the differentiation between loaded and empty trips, distances of transportation, and modes of transport use. After these differences were considered, the approach involved revealing the deviation of the actual volume of fuel reserve maintained by a farm from the optimized one.

Depending on the location of an agricultural enterprise in relation to grain storage facilities, two possible tactics to optimize fuel costs were identified. First, if there is an elevator of sufficient capacity within the distance of 0–60 km from a farm, that farm should use their own fleet of vehicles. In the cases of Group 2 farms, higher deviations of V_s from optimized V_t were observed compared to Group 1. It recorded a lower efficiency of outsourcing in shorter distances. Second, if a farm dispatches grain to an elevator located out of the 0–60 km area, it is reasonable to outsource transportation operations to a specialized agent. In Group 4 enterprises, V_s values were very close to optimized levels of fuel costs, while Group 3 farms experienced higher fuel expenditures when using their own fleet of vehicles for longer distances.

In this paper, the authors attempted to demonstrate a comparison-based pathway using dynamic optimization tools that an agricultural enterprise can use to reduce logistics costs by optimizing fuel expenditures and utilizing the fleet of vehicles properly, depending on the location of a farm in relation to the existing storage and transport infrastructure. The study, however, has certain limitations since various cost factors were not considered in their interrelationship. Particularly, for those farms which employ own fleet of vehicles, a combination of fuel costs management with proper scheduling and routing optimization may make it posssible to reduce logistics costs more effectively. For the farms which tend to outsource transport operations, a more thorough study of the relationship between transport infrastructure and services development, from one side, and transport costs, from the other, is required. Ideally, transport services' development leads to an increase in transport volume and decrease in fares, but this occurs only when there is a competition among transport providers. In practice, in many countries, governments subsidize fuel expenditures at least partly, as well as practice various regulations in transportation services and thus distort the competitive environment. This, in turn, increases indirect expenses, keeps transport prices high, and does not stimulate the parties to optimize fuel consumption. Also, this study was site-specific, and its findings mainly reflect the situation of the transportation of crops by large agricultural enterprises in Russia. In other territories, the studies may require adjustments for some of the parameters, particularly FCR_l and FCR_e, as well as the average distance of transportation from a farm to the receival site. Data collection requires special arrangements since most of the data used in the transformed EOQ model are not readily available from secondary sources, but require on-site collection. Typically, large agroholdings are reluctant to share their logistics data with outsiders, therefore, support from local administration or trade associations may be needed.

The key recommendation that can be drawn from the analysis and discussion presented in this paper is that in agriculture, the management of logistics costs should consider combining the operation of trucks by a farm with the outsourcing of transportation operations to address the fragmentation of transport and storage infrastructure. Dynamic optimization of fuel costs is crucial in fostering the performance of agricultural producers and helping them to overcome the infrastructural constraints they face.

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Article

Land Concentration, Land Grabbing and Sustainable Development of Agriculture in Romania

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Abstract: Land grabbing has become a priority topic in academic research and a political concern, due to interests in the dynamics of the phenomenon and its negative impact on the sustainable development of agriculture in rural areas. This phenomenon generates changes in production systems of agriculture with adverse environmental consequences, adversely affects socio-economic and cultural conditions and leads to lower overall efficiency in agriculture. This article analyses the links between land concentration, land grabbing and sustainable development of agriculture in Romania compared to other old and new EU-28 countries. The results of the research show that the land grabbing in Romania has a significant dimension compared to the other countries analyzed, which has led to an inadequate agrarian structure and adverse effects on the sustainable performance of agricultural holdings and the sustainable development of rural areas.

Keywords: land grabbing; land concentration; sustainable development; agrarian structure; performance

1. Introduction

Agriculture is an essential branch of the economy due to its role in food security, employment in rural areas and biodiversity insurance, as well as in the preservation and protection of the natural environment. As such, the role of the Common Agricultural Policy (CAP) in strategic decisions regarding the future of the European Union seems to be a fundamental issue. Since its launch in 1962, the successive reforms of the CAP have focused on creating more market-oriented agricultural sectors and increasing their competitiveness, as well as improving income support to producers and adapting environmental requirements into the development strategies.

The recent CAP reform of 2013 was integrated into the Europe 2020 Strategy to achieve green growth in the agricultural sector and the rural economy (i.e., smart, sustainable and inclusive growth). Such challenges had the following objectives [1]:

- viable food production;
- sustainable management of natural resources and climate action;
- balanced territorial development.

The CAP reform after 2020 will start from a need to modernize and simplify, so that European agriculture can develop smartly, resiliently, sustainably and competitively. The agricultural sector must provide safe and high-quality food to over 500 million consumers, contribute to the dynamic and sustainable development of rural areas and respond to citizens' expectations regarding quality of life, state of health, the environment and climate. The unique European agricultural model implemented through legislative measures regarding the CAP has focused on increasing the economic viability of farms, improving environmental and weather conditions and strengthening the socio-economic fabric of rural areas. The creative development is a cross-cutting objective implemented by fostering knowledge, innovation and digitalization in agriculture and rural areas. The Multiannual Financial Framework (MFF) for 2021–2027 pursues nine specific objectives through the Common Agricultural Policy: (i) providing a fair income to farmers, (ii) increasing competitiveness, (iii) rebalancing power in the food chain, (iv) determining actions to fight climate change, (v) caring for the environment, (vi) preserving landscapes and biodiversity, (vii) supporting generational renewal, (viii) establishing vibrant rural areas and (ix) protecting food and health quality.

The purpose of our research is to evaluate the link between land concentration, land grabbing and the sustainable development of Romanian agricultural holdings in comparison with other EU member states. The analysis is also useful for countries that joined the EU later, and for European countries with developed agriculture, as some aspects of land grabbing are common, and the achievement of an optimal agrarian structure is an essential issue of agriculture and rural areas in all countries.

Authorities with national and international competence in their respective countries can influence decisions on the land grabbing phenomenon and thus contribute to the sustainable development of agriculture, environment and rural space. The impact of large-scale land acquisitions (LSLAs) is difficult to quantify at present, but must be monitored in the context of the Sustainable Development Goals set by the international community.

The sustainable development of agriculture encompasses new dimensions for each country by including the objectives of the 2030 Agenda into development strategies, including ending hunger, achieving food security, improving nutrition and promoting sustainable agriculture (Goal 2). Romania's National Sustainable Development Strategy 2030 aims to develop a sustainable and competitive agri-food sector to improve quality of life in rural environments. It aims to ensure living conditions similar to those in urban areas, to encourage local and ecological production and to promote traditional and mountain products with added value [2].

The sustainable development of agriculture and rural spaces depends on an efficient use of production factors including agricultural land, the labor force and technical factors. The sizes of farms, depending on the area of land used, have direct economic, social and environmental implications. Excessive fragmentation of the land means the existence of agricultural holdings that have not adapted to the requirements of the market economy, including low incomes for farmers, non-competitive agricultural technologies, small agrarian productions and the impossibility of accumulating capital to achieve economic growth. The existence of exaggerated-scale farms, on the other hand, creates environmental pressures by affecting biodiversity, as well as through the insufficient use of labor in rural areas. These farms can also lead to the destruction of local food traditions, and the practice of a type of agriculture that does not comply with ecological principles and can affect quality of life.

Having farms of an optimum size that are able to use production factors efficiently is a global objective for agriculture on which the food security of populations depend [3]. This process involves land consolidation, but only up to specific dimensions, beyond which the global marginal yield decreases and adverse economic, social and environmental effects begin to appear.

The utilization of land consolidation to achieve appropriate agrarian structures is not a simple process; it started in the second half of the last century and its practice has continued to expand. However, the process is complicated in consideration of objective difficulties related to the functioning of the land market and transaction costs. Other difficulties are also common, including personal issues related to attachment to the land, the establishment and observance of property rights and risk-taking.

The conflicting interests between small farmers and large farms gave rise to the land grabbing phenomenon. This phenomenon often receives the attention of academic literature, media and NGOs, which point out the negative consequences of losing control over the land and restricting family farming, which is characterized by the European model of agriculture.

The Tirana Declaration defines land grabbing as acquisitions or concessions that include one or more of the following: (i) a violation of human rights, particularly the equal rights of women; (ii) the lack of free, prior and informed consent of the affected land-users; (iii) the lack of a thorough assessment, or a disregard of social, economic and environmental impacts, including the ways in which they are gendered; (iv) a lack of transparent contracts that specify clear and binding commitments about activities, employment and benefit sharing; and (v) a lack of effective democratic planning, independent oversight and meaningful participation [4].

The debate on large-scale land acquisitions (LSLAs) is complex and reflects the views of two categories of actors. The first point of view argues in favor of large companies that mobilize capital and control large tracts of land, and supports the need to restructure agriculture by concentrating areas of a sufficient a size to favor the modernization of agricultural systems. These companies focus on intensive technologies and integration into global markets through foreign investment and export growth.

The other point of view reflects the interests of those who traditionally use the land (farmers, pastoralists and indigenous people) and have small farms, who claim that LSLAs threaten human rights, food security, their incomes, quality of the environment and the sustainable development of the rural areas [5]. The impact of LSLAs is difficult to quantify at present, but needs monitoring in the context of the Sustainable Development Goals set by the international community.

Land is not a mere commodity that is traded on the market at a particular value. The transfer of property rights among people makes land ownership is a social relationship, and the connection between people and land amplifies a feeling of national and local identity [6]. Rural landscapes and celebrations related to land cultivation have created emotional connections to rural areas by their inhabitants. This connection is compromised by the loss of ownership of the land.

Land grabbing is a global problem that manifests itself at different intensities. Research shows that the phenomenon is present mainly in Africa [7], South and Central America [8], Asia [9], and former Soviet Eurasia [10]. However, it is also present in Europe, in particular in Central Eastern European countries [11]. In Romania in particular it occurs on a large scale, as foreign investors control almost 40% of the arable area [12].

Land concentration has always been a trend in Europe. Currently, however, it is occurring at an alarming rate, which is likely to affect the sustainable development of European rural areas. The trend is present not only in the states that joined the EU more recently (of which this study recognizes Romania, Hungary, and Poland in particular), but also Germany and France.

2. Methodology

The research illustrated in this paper arises from a need to determine the link between land grabbing and the sustainable development of agriculture in Romania compared to other EU countries.

Since 2000, land grabbing has become an essential concern for the academic community, civil society, governments, corporations and financial institutions. Although the phenomenon is global, there is no accepted definition that fully captures its characteristics. Frequently, specific terms are used to mark the takeover of large land areas, such as “land consolidation”, “land concentration” and “large-scale land acquisition”. These terms are not synonymous; they express the interests of stakeholders who want to highlight the economic aspects of the phenomenon without mentioning the violations of human rights, the negative consequences on the environment or the socio-cultural implications.

The debate on land grabbing becomes complex when considering the social aspects of the phenomenon and their implications on economic development. Opinions are polarized, and arguments are often mutually exclusive. The phenomenon is associated with “Accumulation by Dispossession”, which is the neoliberal variant of the “primitive accumulation of capital” [13]. The two concepts share ideas of the dispossession of peasants from the primary means of production within the limits of the law, the transformation of work into capital and the practice of peasants being forced to work solely as a matter of work.

A remarkable definition provided by Eco Ruralis (a grassroots association in Romania made up of small farmers who practice organic and traditional farming based on environmentally conscious principles) is that land grabbing represents the control of an amount of land that is more significant than the typical local amount, by any person or entity (i.e., public or private, foreign or domestic), through any means (i.e., "legal" or "illegal"), for purpose of speculation, extraction, resource control or commodification at the expense of peasant farmers, ecological agriculture, land stewardship, food sovereignty or human rights [14].

Sustainable agriculture is characterized by all elements of the sustainable development concept, namely, competitiveness and economic efficiency over a long term period that ensure agricultural production systems through healthy eating, increasing the quality of life for people in rural areas, the preservation of natural resources and reducing negative impacts on the environment [15]. To these elements, we can add cultural sustainability, which involves observing and promoting a set of values according to cultural factors, as well as political viability: good governance, democracy and respect for the rights of individuals. We believe that there is an active link between land grabbing and all the elements that characterize the sustainable development of agriculture.

Our research presents disparities in the sustainable development of agriculture between Romania and the other EU Member States based on indicators that characterize performance, economic growth and environmental impact (European Commission).

Agri-environmental indicators are in line with the set of indicators developed by the European Commission that monitor agricultural sustainability [16] and facilitate assessment of the link between land grabbing and environmental impact. Also, our information and concrete data reviews illustrate the effects of land grabbing and other elements of sustainable development in agriculture and rural areas.

To achieve the purpose of this paper, we used a comparative process to determine and analyze the dimensions at which land concentration and land grabbing manifest themselves in Romania and other countries, as well as the influence of the phenomenon on the sustainable development of agriculture.

The comparison highlighted the common elements and disparities between the agriculture situation in Romania and other countries that joined the EU more recently (Poland and Hungary) as well as countries with developed agricultural systems (Germany and France). These countries have similar agricultural potentials, which enables us to draw realistic conclusions following the comparison.

The comparison with Germany and France enables us to realistically contrast the agricultural sustainable development policies in Romania with certain disparities concerning the countries with developed agricultural systems. The comparison with Hungary and Poland shows the position of Romania vis-à-vis two countries that have implemented similar agricultural reforms.

The definition and characterization of the land grabbing phenomenon and land concentration are based on academic literature, on studies promoted by national and international bodies and on the concerns expressed in the media of various NGOs. Land grabbing is a complex phenomenon that occurs on the border of legality and morality, and assessments can be contradictory as they depend on a diverse set of interests.

This research has had difficulties due to a lack of real data regarding the magnitude of the land grabbing phenomenon in Romania, but also in other EU countries. Therefore, the argumentation of real situations is based on a synthesis of information published in public documents. Most of the data used to assess the disparities regarding the sustainable development of agriculture holdings in Romania and other EU countries came from the Eurostat database. The data were processed and presented in tables and charts, based on which we extracted our interpretations. Random factors generated by the climatic conditions can also have an effect on agriculture, and for this reason some series of data related to the performance of agricultural holdings were dynamic.

3. Discussion

Farmland is the essential natural resource on which the food security of future generations depends, and for this reason its proper management is a matter of social, moral and ethical responsibility. Agricultural land is not only a critical production factor, but also the bearer of the rural landscape and of civilization itself. The ownership and control of land that is passed down through generations provides a sense of security to the inhabitants of the rural area. The establishment and existence of national states are related to the territories that belong to them, and according the land facilities and economic activities that are developed thereupon. The regulation of international relations based on a concept of the free movement of goods, services, labor and capital has not provided the instruments required to protect landed property [17].

The acquisition of agricultural land is a phenomenon that has manifested itself throughout history. However, the magnitude and goals of purchasing land have recently reached new dimensions with the potential for unforeseen economic and social consequences that can affect the quality of the environment and life in rural areas. Large-scale land acquisitions lead to the existence of small numbers of agricultural holdings that concentrate and control large tracts of land. These acquisitions change the small-scale agrarian production models that have traditionally been used by family workforces, and restructures them into large-scale agricultural production systems that are based on intensive and commercially oriented technologies [18].

Economic factors can lead to a renunciation of land properties by small farmers, in particular the low competitiveness of the market. In addition, young people often prefer urban civilization to the detriment of the rural culture and government policies, including CAP subsidies, which favor large farms [19]. Nevertheless, a farmer's attachment to their land is usually secure, but often coercion, cheating or orchestrated publicity are used to create confusion, in order to take control of their land.

Land grabbing in the EU is favored by several factors, including: differential land prices; land speculation and land "artificialization" (the change of land use from agriculture to urban sprawl, real estate or an enclave of tourism); processes of land privatization and land consolidation; a variety of EU agricultural, food and energy policies (e.g., its biofuels policy); and EU trade, financial and investment policies and subsidies [20].

The study conducted by the European Parliament's Committee on Agriculture and Rural Development synthesizes the negative consequences of farmland grabbing in the EU, and specifically the disappearance of family farming and the problem of "entry denial" (currently, many rural young people in the world, including Europe, do not want or cannot become farmers for economic reasons such as lack of capital and low remuneration, but also for non-economic reasons such as an attraction to urban living). Other consequence specified are the rise of large agricultural corporations; threats to European food security, food sovereignty and local food cultures; rural unemployment; emigration; and land degradation and decline.

Nonetheless, land grabbing is not an illegal or immoral practice in all cases. The phenomenon has a variety of manifestations related to the actors involved and the forms used, such as purchase or leasing by economic entities—usually multinational entities, banks, insurers, investment funds, speculators or industrial farms. Other forms include masked purchasing through "pocket contracts" (contracts that aim to find "solutions" to the legal restrictions regulating the land deals), purchase under a masked identity and illegal retrocession.

The subsidy scheme of the CAP has accentuated land grabbing and is directly related to owned agricultural areas (subsidy per hectare of farmland). The decreased return on the capital invested in industrial production and increased risk on the financial derivatives market, plus new demands from bioenergy, are all factors that have led to increased land demand and the migration of financial capital towards the agricultural sector.

The increased demand for land has inevitably led to an increase in agricultural land prices and rents. The disparities regarding farmland prices and rents have also favored large-scale land acquisitions [21], a phenomenon that has been especially present in countries where prices are still low and legislation regarding agricultural land acquisition by foreign citizens is favorable. In Romania, this type of difference is still present in different agricultural areas, and the demand for land continues to be dynamic.

4. Results

4.1. Land Grabbing in Europe

Even though the land grabbing phenomenon is often described as being limited in the EU compared to other continents, it is currently experiencing an accelerated dynamic, and the concentration of agricultural lands is a real concern for the people promoting the CAP. Based on statistical data, the European Parliament estimates that in 2013 only 3.1% of farms controlled 52.2% of the farmland in Europe, and 76.2% of farms had the use of only 11.2% of the agricultural land [22]. Starting from the adverse effects of agrarian land concentration, the Resolution adopted by the European Parliament proposes measures to limit the phenomenon and facilitate farmers' access to land.

Land grabbing has its particularities in each country in terms of size, causes and implications. To limit the phenomenon, concrete measures have been established.

In France [23], the land policies were modified profoundly to guarantee the ownership of land by small farmers. However, these policies now have undesirable side effects, because they prevent fair access to the property, particularly access for young farmers who do not come from agricultural families. By stipulating strict rules in the leasing contracts, the conflict between landowners and farmers favors the latter. The monitoring of farming structures established in the 1960s provided a government license to work the land. The licenses granted by the local commissions gives priority to new farmers and farms that are too small to be viable. Further, the society for land planning and rural establishment (SAFER) was set up at the local level and aimed to prioritize agricultural land use, restructure farms and settle new farmers by purchasing agricultural lands and reselling them to other farms. There are severe restrictions on the purchase of property in France, but even so these can be circumvented. An example is the Bordeaux region, where Chinese investors have bought about 100 vineyards.

Land acquisition in France is difficult for new farmers due to land grabbing, "artificialization" for non-agricultural projects and land concentration within the farming sector. The level of land in France was encouraged by CAP subsidies and environmental regulations. In 1955, 80% of all farms in France had less than 20 ha; the average size today is around 80 ha.

Of course, the situation of the land areas owned by agricultural holdings in Germany bears the imprint of the reunification of East Germany with West Germany. The existence of smaller fields in the West and larger areas located to the East of Elbe River characterize the farming landscape [6]. The land retrocession after 1989 to the former owners who possessed less than 100 ha during the German Democratic Republic times and had been expropriated between 1945 and 1949, were made by purchase, at a reduced price, from the Land Administration and Privatization Agency (BVVG Bodenverwertungs- und -Verwaltung GmbH). Between 1991 and 2012, the number of holdings of more than 5 ha has halved due to an accelerated process of land concentration [24]. Major investors control large areas of land (KTG Agrar, a financial investor specializing in large farming operations controls more than 38,000 ha). This process implies a substantial erosion of culture and social life in rural areas.

As a result of the agricultural land concentration that manifested in Germany and the consequences of this phenomenon, legislative measures were adopted to limit the practice. The German Constitutional Court ruled in its judgment of 12 January 1967 (1 BvR 169/63, BVerfG 21, 73-87) that the trade of rural lands need not be as free as the trade of other capital, as the land is unrenewable and indispensable. An equitable legal and social order requires the public interest in land to be taken into account far more than in the case of other properties [22].

In Hungary, the formal statistical data show that the size of farmland grabbing is insignificant, because the legislation regarding the acquisition of agricultural land by foreigners is restrictive. However, in the last two decades, approximately 1 million ha of land has been bought by foreigners through "pocket contracts". After the legal restrictions on the sale of land were removed, the respective contracts were registered. In 2015, the government initiated a tender programmed to sell agricultural land to farmers (Hungarian citizens living in Hungary), including about 200,000 ha in 10 ha plots, which were granted through preferential loans.

Poland does not formally prohibit the purchase of agricultural land by foreigners, but the conditions imposed on the purchase of estate are restrictive. Foreigners may purchase a property if they meet the following requirements: they are married to a Polish citizen, and she/he has been living and doing farming in the country for at least three years. If these conditions are met, the particular plot rented by her/him may be bought [25].

To the above restrictions should be added the active intervention of the state in the sale of agricultural land by exercising the right of pre-emption and redemption by the state to purchase land in private circulation then sell it to individual farmers on a preferential basis (through the Agricultural Property Agency). Also, the purchaser must run a farm personally for 10 years. Currently, due to these restrictions, the threat of land grabbing in Poland is not considered to be significant [26].

The political changes in the Balkans after 1989 caused by the fall of communism and Yugoslavia's disintegration led to the privatization of agriculture. New agricultural structures have often proved inefficient, and as a consequence land grabbing has been favored.

In Serbia, the privatization of agriculture has hastened as a result of poor regulations regarding land property. After the sale of agricultural enterprises, the Privatization Agency granted the right of land use to the new owners only, and registered these areas in the real-estate registry as the owners' private properties [27].

This non-transparent privatization process favored land grabbing. The four largest farms in Serbia together now hold over 100,000 ha of land, and the subsidies offered by the state and the Serbian Stabilization and Association Agreement with the EU that allows foreigners to buy property have led to higher land prices and speculation. Ending land grabbing is possible only through the joint action of the organizations to provide viable alternatives in agriculture and by increasing the social pressure applied from the worker–peasant movement in Serbia.

After the fall of communism, land reform in Bulgaria went took two forms: (i) the dissolution of state-run, large-scale cooperatives, and (ii) the restitution of land owned before the collectivization of agriculture in 1946. The liquidation took place quickly and was marked by massive corruption, while land restitution took a long time and led to severe fragmentation in land ownership [28]. This aspect later favored land grabbing because, in many cases, the new owners were not interested in agriculture. Subsequent land use legislation has allowed local governments to redistribute agricultural land (if there is no intention to use it) to investors, who use the law to seize their property.

4.2. Characteristics and Examples of Land Grabbing in Romania

In almost all studies referring to land grabbing in Europe, Romania is presented as the country where the phenomenon manifests itself with maximum intensity. Data on the size of this has generated conflicting opinions, as the land cadaster, which records the ownership of land in Romania and the ways in which land has been acquired, is far from complete.

According to the data provided by the Ministry of Agriculture and Rural Development (MARD), out of a total of 9.57 million ha of agricultural land subject to Agency for Payment and Intervention in Agriculture (APIA) grants, only 3.87 million ha (40%) are included in the integrated land registration system. No subsidies are granted for 2 million ha of arable land in Romania because they are abandoned or not eligible to get support, with the plots of land being too small (less than 0.3 ha).

According to the MARD data, the area of agricultural land used by foreign individuals and legal entities was 422,000 ha at the end of 2018 (4% of the UAA). The press information presents another reality, stating that 40% of agricultural land is now in the hands of investors from outside the EU, with a further 20%–30% being controlled by investors from the EU [12]. This information refers only to agricultural lands controlled by foreigners, some of whom control vast areas (the Lebanese company "Lebanese Farm" has 65,000 ha). However, some Romanian investors control large areas of arable land, such as the Romanian agri-food company "Transavia", which cultivates around 12,000 ha of cereals (this is a leased land located in the surroundings of Cluj [29]).

A way to control land is through the agricultural market, which in Romania operates as an oligopsony market. Small farmers do not have a grain storage capacity, but some companies have acquired or built huge storages.

Based on agricultural contracts, these companies influence agricultural production and prices. An example in this regard, provided by Eco Ruralis, is the Cargill Incorporated case, which, through the 18 silos owned by the company in Romania, controls 250,000 ha of agricultural land.

The reasons Romania attracts investments in agricultural land vary. There are large areas of land with pedoclimatic conditions that are favorable to agriculture, where the existing European subsidies and government support large-scale investors, and the rural population is ageing and often has no capital to finance agricultural activities. Of course, the low price of land in Romania (as compared with Western European countries) also attracts foreign investors.

The data presented in Table 1 show that Romania has the lowest price of land in the EU. In the Netherlands, the cost of land is 30 times higher. In Poland, which has agricultural characteristics similar to Romania, the price of a property is five times higher.

Table 1. Price of land (Euro/ha).

Country	2011	2012	2013	2014	2015	2016	2017
Germany	Data for Germany are not available						
France	5.390	5.440	5.770	5.940	6.000	6.070	6.030
Hungary	2.089	2.380	2.709	3.042	3.356	4.182	4.368
Poland	4.855	6.080	6.275	7.723	9.220	9.083	9.699
Romania	1.366	1.666	1.653	2.423	2.039	1.958	2.085
Denmark	17.476	17.562	15.708	17.209	18.752	17.584	17.328
Italy	34.257	39.342	32.532	39.247	40.153	28.985	33.538
Netherlands	50.801	52.716	54.134	56.944	61.400	62.972	68.197

Source: Eurostat, Agricultural land prices by region, [30].

At the same time, an increase in the price of land can be observed over the period analyzed, especially in the countries that joined the EU more recently (e.g., Hungary, Poland and Romania). Natural factors, as well as spatial and organizational factors, influence the prices of agricultural properties. Taking all these factors into account, the price of land in some parts of Romania is approaching the price of land in Western Europe. Even if the price of land is low in Romania, it is still high for the population living in rural areas, a fact that prevents its purchase by the inhabitants of those areas and favors land grabbing by foreigners.

Among the factors that have led to a recent increase in the price of land are a decrease in land supply and the direct subsidies granted per area—the former because many owners already sold their land before 2011, which makes land ownership profitable even if the owner does not work it directly. Land rent is higher than the yield of other investment categories. Research shows that there is a lag in cash rents before they match the level of land prices [31].

The manner in which land grabbing took place in Romania took place has, in many situations, the characteristics of "Accumulation by Dispossession" and the "primitive accumulation of capital". The transition period to a market economy in Romania involved structural reforms in the economy and a massive loss of employment from industry and state or cooperative agriculture. Restitution of land created a false alternative to available employment. Fragmentation of the land, and lack of capital, led to the formation of subsistence and non-competitive farms. In this situation, the agricultural land was sold at low prices or leased, and the old owners engaged in new capitalist farms or in other economic branches that were revived. Many rural residents migrated, or moved to urban areas that offered them better jobs.

4.3. Economic Structures in Agriculture

Land concentration is a process that has more recently accelerated in Europe. In the 2005–2016 period, the number of farms decreased in Europe by 4.2 million (about 25%), of which 85% were small farms of less than 5 ha. Significant reductions in the numbers of farms occurred mainly in Romania (0.8 million farms (i.e., 20%)), Poland (1.1 million farms (i.e., 44%)) and Italy (0.6 million farms (34%)), and reduced by almost two-thirds in Slovakia and Bulgaria [32]. The decreasing number of small farms occurred in parallel with an increase in the area of land owned by big farms, which shows that small farmers were losing control and power over their land.

Romania is a country where pedoclimatic conditions are among the most favorable in the European Union. This aspect, along with its traditions, are prerequisites to excellent quality productions in significant quantities, which can satisfy the domestic demand and provide important export availabilities based on a comparative advantage.

The agricultural area used in Romania is over 12.5 million ha (sixth place in the EU). Still, its agrarian structure is inadequate and not in line with the agriculture of developed EU countries, being somewhat similar to the states of Latin America. The inadequate agricultural structure is the leading cause of the low performance of Romanian agriculture compared to the agriculture of the developed European countries.

Research on the relationship between farm size and economic performance has led to conflicting results. Some studies consider that there is a direct and positive connection [33], while others have demonstrated an inverse relationship [34]. Additionally, some research findings have supported the existence of a nonlinear relationship [35]. Our study confirms the presence of a connection between the size of farms and their sustainable performance, and proposes the transformation of subsistence farms into small- and medium-sized commercial farms [36].

Romania has an outstanding agricultural potential (Table 2). It owns 7.2% of the utilized agricultural area of the EU-28, being close to the agriculture of Germany (9.7%) and Poland (8.3%). The population employed in Romanian agriculture represents 20.1% of the farm labor force of EU-28. We see that Romania has an almost four-times-higher labor force in agriculture than Germany. Still, the figures must be interpreted with caution, because most of the population employed in Romanian agriculture as recorded in the formal statistics do not earn their primary income from agriculture, and have other occupations or have retired from work.

Table 2. Number of holdings, utilized agricultural area and farm labor force in 2016.

Country	Number of Holdings		Utilized Agricultural Area (UAA)		Average Area per Holding, Hectares	Persons Employed in Agriculture		Farms for Self-Consumption %*
	in Thousands	% of EU 28	in 1000 Hectares	% of EU 28		in thousands	% of EU 28	
EU28	10,467.7	100.0	172,967	100.0	16.52	9,720.6	100.0	-
Germany	276.1	2.6	16,715	9.7	60.54	576.0	5.9	0
France	456.5	4.4	27,814	16.1	60.93	710.0	7.3	1.54
Hungary	430.0	4.1	4,671	2.7	10.86	247.3	2.5	59.79
Poland	1,410.7	13.5	14,406	8.3	10.21	1,608.8	16.6	18.36
Romania	3,422	32.7	12,503	7.2	3.65	1,960.3	20.1	86.39

Source: Own calculations based on Reference [32].

According to information in the press, Romanian farmers often complain about the lack of a labor force in livestock farms.

Romania's agriculture has 32.7% the number of holdings in the EU. Still, a large number of small farms practice subsistence agriculture (86.39% are farming for self-consumption). Romania has the highest number of agricultural holdings in the EU, but they are inhomogeneous, with most of them being small or having a very small size, while some are very large. The restoration of land ownership in Romania after 1989 created this situation, which led to the excessive fragmentation of agricultural land

and the establishment of a large number of agricultural holdings, followed by the property grabbing phenomenon that led to farms with extensive areas.

Land grabbing has produced significant changes in Romania's agrarian structure by reducing the number of small farms and through the emergence of farms that control vast areas of land. The number of tiny farms (having small areas of agricultural land) remains very high compared to other countries. The data in Table 3 show that 91.8% of the total numbers of farms in Romania are small farms that use less than 5 ha of agricultural land. However, they control only 28.7% of the utilized agricultural area in Romania. At the same time, large farms, which use areas of more than 100 ha, represent only 0.4% of the total number of farms, but they control 47.8% of the utilized agricultural sector. This agrarian structure is not compatible with the European model of agriculture practiced in Western European countries.

Table 3. Distribution of farms and utilized agricultural area, according to farm size, in 2016 (%).

Hectares	Farms, UAA	GE	FR	HU	PL	RO	EU-28
0-4.9	Farms	8.6	24.3	81.4	54.3	91.8	65.6
	UAA	0.2	0.8	4.8	13.2	28.7	6.1
5-9.9	Farms	16.1	9.2	6.4	21.7	5.7	12.1
	UAA	1.9	1.1	4.1	15.0	10.4	5.1
10-19.9	Farms	20.1	9.0	4.7	14.3	1.5	8.3
	UAA	5.1	2.1	6.0	19.3	5.3	7.0
20-29.9	Farms	9.7	6.0	2.0	4.3	0.3	3.5
	UAA	4.0	2.4	4.4	10.2	2.1	5.1
30-49.9	Farms	14.4	10.3	1.8	2.9	0.2	3.6
	UAA	9.3	6.7	6.3	10.6	2.3	8.5
50-99.9	Farms	17.4	19.4	1.7	1.6	0.2	3.6
	UAA	20.3	23.2	11.0	10.6	3.3	15.5
>100	Farms	13.3	21.9	2.0	0.9	0.4	3.3
	UAA	59.1	63.8	63.4	21.1	47.8	52.7

Note: GE -Germany, FR –France, HU –Hungary, PL –Poland; RO –Romania. Source: Own calculations based on Reference [37].

One notices that the distribution of the utilized agricultural area and the number of farms in Germany and France are more uniform, and that the share of medium farms is higher.

4.4. Disparities in the Sustainable Development of Agriculture

The structure of land ownership raises questions about the possibility of achieving the sustainable development objectives of Romanian agriculture, and leads to profound disparities between Romania and other countries.

The data presented in Table 4 summarizes the sustainable performance of Romanian agriculture compared to the EU-28 and the individual countries analyzed. The value of total agricultural output is an indicator often used in international comparisons to express the performance of agriculture. Agricultural production per hectare in Romania is 53% of the EU-28 average, and almost three times lower than in Germany. Gross value added (GVA) synthetically expresses the creation of the value resulting from the use of production factors. GVA is considered an essential item in measuring productivity, and the value obtained in Romania's agriculture is 57% of the EU-28 average.

Table 4. Economic disparities in agriculture (Euro/ha) in 2017.

Indicators	GE	FR	HU	PL	RO	EU-28
Agricultural output	3309.58	2531.01	1763.92	1775.7	1271.46	2397.06
Gross value added (GVA) at basic prices	1249.3	1061.6	762.9	739.9	616.7	1086.6
Fertilizers and soil improvers	127.2	120	99.8	113.4	54.1	97.7
Plant protection products, herbicides, insecticides and pesticides	108.2	117.7	84.2	81.7	26.2	73.6
Fixed capital consumption	576.5	376.6	209.1	120	208.8	354.8
Energy, lubricants	200.1	133.8	137.4	232.4	149.8	254.9
Interest paid	65	25.2	0.3	21.4	6.1	36.9
Agricultural service	139.4	161.8	92.8	36.8	16.6	105.6
Gross fixed capital formation (GFCF)	555	361.7	186.6	87.4	85.7	333.2
Labor productivity in agriculture *	28,149.5	36,426.3	7546.9	4178.9	5096.2	17,148.1
Cereals to produce grain (including seed) to/ha	7.26	7.25	5.82	4.12	5.22	5.57
Milk yield - kg/cow	7763	6956	8064	6361	3231	7021
Share of UAA under organic farming (%)	6.8	6.0	3.7	3.4	1.9	7.0
Total net emissions from agriculture1000 t of CO_2 equivalent	98,555.5	82,927.2	6587.3	7589.6	16,098.0	490,098.2

* GVA (at basic price—in euros)/AWU, average 2014–2016, Source: Own calculations based on Reference [38].

Romania has favorable conditions for agricultural crop and livestock production. However, yields and labor productivity in agriculture are low. The crop yield (kg/ha) in Romania is below the EU-28 average, the milk yield (kg/cow) is less than half and labor productivity is less than a third.

Reduced use of certain factors with a direct influence on the growth of production determined disparities between Romania and the EU-28. The use of fertilizers and soil improvers by the farm holdings of Romania is 55% of the EU-28 average, and the consumption of plant protection products, herbicides, insecticides and pesticides represents only 35%. The mechanization of agriculture is still deficient in Romania. This situation is demonstrated by the fixed capital consumption (58.8% in Romania compared to the EU-28), as well as the low use of energy and lubricants.

Agricultural services are an essential component of intermediate consumption in agriculture, and contribute to an increased agricultural performance. It must be specified who will carry these specialized services out, as well as what specific investments are required. That is why farmers prefer to hire companies that specialize in providing agricultural services [39]. In Romania, purchased agricultural services are more than six times lower than the EU-28 average.

Agricultural credit is vital for agriculture both for financing production (the production cycle in agriculture is long) and investments, as well as for the personal financing share required by projects carried out with the help of agricultural structural funds. In Romania, the loans granted to agriculture by the banking system are below the EU-28 average, and the level of interest paid for capital loans is more than six times lower than the EU-28 average, even though the cost of borrowed capital is higher than in the other European countries.

The reduced possibilities of financing agriculture in Romania cause significant difficulties in financing investments for the purchase of land, buildings, machines, vehicles and other equipment. The gross fixed capital formation (GFCF) in Romania's agriculture is almost four times lower than in the EU-28.

Sustainable agriculture involves production processes that are able to protect the environment and human health. For this, the conversion of agricultural land and the implementation of organic farming practices represent a chance for Romania due to the reduced consumption of fertilizers and pesticides in recent years. However, the share of the total green crop area out of the total UAA is low in Romania compared to the other countries analyzed in this research. Emissions from agriculture (carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) from agricultural soils), which are responsible for climate change and its effects on the environment and (implicitly) on agriculture, are lower in Romania compared to the other analyzed countries.

The agriculture of Romania is mostly dependent on climatic conditions. The agrarian structure of Romania does not favor investment in irrigation systems, ensuring safe and stable productions.

The influence of climatic conditions explains the variations in the cereal yield during the 2007–2017 period in Romania and Hungary. Figure 1 shows the significant differences in grain yields in the analyzed countries—differences that remained almost unchanged throughout the analysis interval.

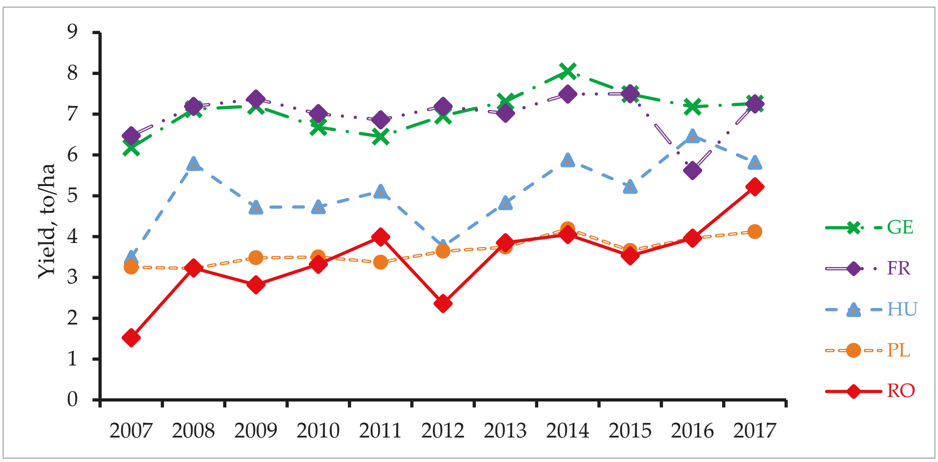

Figure 1. Cereal yield, 2007–2017. Source: Eurostat; Crop products: areas and productions [38].

Ensuring the sustainable management of natural resources is a strategic objective that is necessary in order to achieve the sustainable development of agriculture. Quality of life and the future of new generations depend on achieving this goal. Land grabbing is a driver of environmental change [40]. Through promoting agriculture practices, this phenomenon affects air, soil and water quality, as well as the safety of ecosystems. An analysis based on agri-environmental indicators (Table 5) highlights substantial environmental disparities between Romania and the other countries analyzed.

Table 5. Environment disparities.

Indicators	GE	FR	HU	PL	RO	EU-28
Agricultural areas under Natura 2000, % of agricultural area, for the year 2016	10.2	7.1	11.9	11.4	11.1	9.3
Area under organic farming, % of UAA, for the year 2018	7.34	7.01	3.92	3.33	2.43	7.50
Water quality: Nitrate pollution (mg NO3/l, for the year 2013	622	1656	N.a.	112	659	N.a.
Estimated soil erosion by water: area affected by severe erosion rate, %, for the year 2016	1.3	3.27	2.51	1.14	7.31	5.25
Climate change: Greenhouse gas (GHG) emissions from agriculture, share of agriculture in emissions of GHG, %, for the year 2017	7.1	15.8	10.9	7.6	13.8	16.8
Irrigation: share of irrigable and flooded areas in a utilized agricultural area, % of UAA	4.0	9.7	4.9	1.9	2.7	N.a.

Source: Eurostat, agri-environmental indicators, [41].

The natural environment in Romania is "characterized by good preservation of natural resources of soil and water, variety of traditional landscapes and a remarkable biological diversity" [42]. The challenges of agriculture development and other economic branches can seriously affect the quality of the environment as a result of climate change, deterioration of natural balance, degradation and depletion of resources. Biodiversity is threatened by land grabbing due to the replacement of traditional agricultural practices based on existing technologies, with intensive technologies that lead to changes in the countryside and threaten the diversity of accompanying fauna and flora. Land grabbing contributes to the transformation of local farming environments through monocultures that are needed to cover the demand for biofuels, which affects ecosystems. To address this challenge, the European Union created the Natura 2000 instrument, which comprises a network of natural or semi-natural areas, so-called SCIs (Sites of Community Interest) and SPAs (Special Protection Areas), because vulnerable plant and animal species and natural habitats must be protected. This tool was based on the 1979 (amended in 2009) Birds Directive [43] and the 1992 Habitats Directive [44]. Romanian agricultural areas under Natura 2000 are in a proportion similar to the other countries analyzed.

Water is one of the critical resources necessary for the sustainable development of agriculture worldwide, and irrigation is an objective necessity [45]. Irrigation can provide the water necessary for plants to obtain optimum yields, high-quality harvested crops and sustainable agricultural production.

Of course, irrigable and irrigated agricultural areas vary significantly among countries. Romania poses a significant risk to climate change, which is reflected in changes in the temperature and rainfall regime over the past 40 years. An essential part of Romania's agricultural area is currently experiencing the harmful effects of drought, insufficient water supply and insufficient and poorly functioning irrigation facilities.

The irrigation system in Romania was built before 1990 and covered about 22% of Romania's arable surface, but was later left in ruins. Currently, more than 75% of irrigation facilities are not functional, and functional ones are inefficient in terms of water and energy consumption, resulting in high expenses for farmers [46]. We note that the share of irrigable and irrigated areas in utilized agricultural land is lower in Romania compared to most of the countries analyzed in this study. Land grabbing may constitute a significant obstacle to the expansion of irrigation systems because it involves substantial investments that farmers are often unwilling to make.

Organic agricultural development constitutes a priority for the Common Agricultural Policy, and represents an opportunity for Romanian agriculture [47]. In vast areas, organic farming involves traditional practices that are incompatible with extensive techniques. Land grabbing adversely affects the development of organic farming and is one of the leading reasons why the share of the agricultural area under organic farming is lower in Romania than in the other countries analyzed, and well below the EU-28 average.

Ensuring that the necessary quantity and quality of water resources are available is essential to living conditions in general and for carrying out human activities. The role of water in environmental systems through economic and social activities shows that it is an indispensable resource in the lives of living people and organisms. Water resource management involves ensuring water of a sufficient quality in the necessary quantity.

Increasing demand for food is associated with increasing the pressure on freshwater resources. About 86% of freshwater resources support agricultural activities. The implications of land grabbing on water resources have previously been recognized [48]. Large-scale irrigation causes water stress and poor water quality. Intensive agricultural technologies have been responsible for the pollution of surface waters and groundwaters (through fertilizers, pesticides, nitrates and nitrites). In Romania, water resources remain of a relatively good quality, but nitrate pollution is higher than in Poland or Hungary (although it is lower than in France).

Soil erosion by water is one of the big problems contributing to soil degradation in Romania. This issue affects 7.31% of agricultural land, which is above the EU-28 average and higher than in all of the other countries analyzed. This phenomenon reduces farm viability, destroys vegetation and landscape architecture and affects water quality. The increased risk of erosion is due to many lands being abandoned in winter, and the frequent performance of short agrotechnical works. Forest grabbing in Romania [49] also contributes to soil erosion by water through the abusive logging of forests.

Global climate change affects genuinely sustainable development through negative consequences toward the environment, economic activities and (implicitly) quality of life. Among the factors influencing climate change in recent decades has been the increase in greenhouse gas (GHG) emissions. Agricultural production and implicit food security are deeply affected by climate change. At the same time, intensive agricultural practices contribute to the growth of greenhouse gas emissions such as methane (CH4), nitrous oxide emissions (N2O) and carbon dioxide (CO2). Land grabbing fosters climate change [50,51] by affecting ecosystems and increasing greenhouse gas emissions as a result of land-use change (deforestation for the expansion of arable land), large livestock farms and the widespread use of organic and inorganic fertilizers. In Romania, the share of agriculture contributing to emissions of greenhouse gases is below the EU-28 average, but higher than in most of the other countries analyzed except for France.

4.5. Recommendations Against land Grabbing

The development of agriculture in Romania will require the adoption of a set of measures to eliminate the factors that generate the current disparities with the EU, and that will create premises for the development of sustainable agriculture. Of course, it is necessary to reduce the excessive fragmentation of the land, which is still maintained, but also to avoid excessive concentration via land grabbing.

In order to reduce land grabbing, we consider it necessary that these measures be in line with national and international agricultural policies, mainly the CAP, which can be converted into appropriate legal regulations and concrete actions by the government and local decision-makers. The principles of the new agrarian governance must guarantee property rights.

The single-dimensional approach of the formalization of property rights is not enough, because it does not consider the power imbalances between the actors involved and cannot be applied in all systems of traditional agricultural production [52]. A real guarantee of land ownership rights requires a multidimensional approach. The documents adopted by the European institutions [53,54] propose several measures to regulate the agricultural land market in order to prevent land grabbing and land concentration.

A reform is need of the CAP, which has favored an increase in agricultural holding sizes through the Single Payment Scheme (now becoming the Basic Payment Scheme). In this respect, the following measures may be adopted: the introduction of direct payment ceilings; the use of redistributive payments that favor small farmers; coupled payments, to strengthen sectors in difficulty; the implementation of new greening policies; and an increase support for young farmers and small farmers.

Land is not a "commodity" but rather a "finite transnational resource" that must be governed responsibly according to sustainable principles. The use of land for agriculture should be in line with environmental protection, and therefore food production should be prioritized over agri-fuel production.

The free movement of capital is a sovereign principle of the functioning of the market in the EU. However, in the case of land, regulations should be included, including higher limits on the purchase of agricultural land. Local agricultural communities must be involved in significant decisions on land destinations. Local and national authorities must have real information on ownership and land use, and permanently updating the cadaster is a priority.

Land grabbing issues cannot be solved only by European institutions or authorities of the Member States. It is necessary to consciously involve farmers who are associated in viable agricultural structures voluntarily. Agricultural cooperatives are an essential option for increasing the competitiveness of small farmers.

The involvement of civil society is also crucial for stopping the phenomenon of land grabbing. An example of this is the French citizens' initiative "Terre de Liens", which supports family farming, local food and agricultural production [12].

The realization of a complete agreement between the structure of land ownership, the use of the earth and the sustainable development of agriculture constitutes a current model for good land governance.

5. Conclusions

The agrarian structure characterized by the number and size of agricultural holdings has a significant influence on the sustainable development of agricultural holdings. In Romania, the agrarian structure is the result of economic policies implemented after 1989 that led to the excessive fragmentation of the land and favored the manifestation of the phenomenon of land grabbing.

The results of the present research show that land concentration and land grabbing pose a significant threat to the sustainable development of agricultural holdings and rural areas due to their adverse social effects, and their cultural and environmental impact. At the same time, excessive land fragmentation is undesirable because it goes against the principles of economic rationality. These considerations demonstrate the need to adopt adequate policies in order to realize a land ownership structure that enables the practice of sustainable, multifunctional and competitive agriculture in which family farms play an essential role.

In Romania, agricultural land is not always purchased for agricultural purposes. The increase in the price of agricultural land has led to speculation, which has benefited those with financial resources. The subsidies granted by the EU, represented by direct payments calculated per land area, have also led to an increased interest in agricultural lands. In Romania, legislation on land acquisition is more permissive than in other EU countries.

Land grabbing occurs at different intensities in each EU country. In Romania, the phenomenon has reached alarming proportions, and this—along with the excessive fragmentation of the land—has led to poor agricultural performance compared to other EU-28 countries. The technical and financial capital used in Romania's agriculture is lower than in other countries and, consequently, the yields obtained in crop and livestock production are also lower. One reason why organic farming, which is an essential component of sustainable agriculture development, is still poorly represented in Romania is land grabbing, which involves industrial-scale agriculture. The concentration of land in extensive agricultural holdings makes it difficult for the young generation to access agricultural land, and the ageing of the population employed by Romania's agriculture—although that population remains statistically numerous—threatens the viability of rural communities.

Land regarded not as a commodity, but rather as an essential resource for food security and safety, therefore, is an essential means of existence for today's and tomorrow's generations. In this manner, the policies for proper land use are essential for all countries based on the subsidiarity principle (where a decision, the effort and the responsibility belong to each country). At the same time, the principles on which the EU has been established, require appropriate changes within the CAP.

For Romania, the adoption of appropriate land policies that are able to protect property and limit land grabbing is an urgent national security issue [55], which is why there are concerns about modifying the legislative framework that regulates land sale. However, other economic and social measures accompanying this legislation should guarantee the use of the land based on principles of economic rationality and a high standard of living in rural areas.

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New Evidence for Romania Regarding Dynamic Causality between Military Expenditure and Sustainable Economic Growth

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Abstract: Military spending and sustainable economic development have been widely discussed in recent decades. Especially in Romania, the defense budget is valued at $4.8 billion, registering a compound annual growth rate (CAGR) of 23.57%. It is also expected to reach $7.6 billion in 2023, according to a report by Strategic Defense Intelligence. There is no consensus in current research and less attention is paid to Eastern European countries. Considering the significant increase in military spending in Romania in recent years, as well as the occurrence of political events, this paper focuses on the dynamic causal relationship between military spending and sustainable economic growth in Romania. The bootstrap rolling window causality test takes into account the structural changes, and therefore, provides more convincing results. The results indicate negative effects of military expenditure on sustainable economic growth between 1996–1999 and 2002–2004. It can be attributed to the crowding-out effect of public expenditure on private investment. The positive effect between the two variables analyzed is noticed with the accession of Romania to the North Atlantic Treaty Organization. Conversely, it is found that economic growth does not have a significant effect on military spending in Romania. Policymakers should guard against the crowding out of private consumption and investment due to excessive military spending and ensure to increase military expenditure on the premise of sustainable economic development.

Keywords: military expenditure; economic growth; sustainable development; bootstrap rolling-window Granger; crowding-out effect

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1. Introduction

Considered to be one of the most important budget expenditures, military expenditure (ME) has played a significant role in macroeconomics over time. At this time, many studies have tried to explain the relationship between ME and GDP [1–3]. According to the studies, a substantial amount of budgetary provisions in many developing countries is heading for defense and security, and most of the time they are at the expense of allocating them for economic, social, and investment services. Therefore, the "guns for butter" theory points out that the increased ME results in lower resource allocation in other productive economic sectors, such as education and healthcare, and then hinders sustainable development. From this perspective, the allocation of budget expenditure has raised serious concerns among researchers and decision-makers, considering the role of military spending in sustainable economic growth.

Starting with the analysis period of 1980 in Romania, the annual budgetary laws elaborated until 1989 could be considered a paradox of the socialist system in our country. Although the overwhelming role of the state in a centralized economy was promoted, the socialist state relied on the "golden rule" of the budgetary balance in classical liberal theory. Therefore, budgets were built on income approaches, not related to the public expenditure of the political leadership that exerted the state power after 1989. Depending on the accumulated revenues, expenditures were planned, the changes that could have existed due to the occurrence of provisions, the achievements reflecting budgetary surpluses.

Since 2000, the budget for military expenditures has also been set by taking into account the costs of ensuring interoperability in the Euro-Atlantic integration actions. Moreover, other important goals were considered when establishing military expenditures, such as participation in peacekeeping operations for the involvement of the Romanian Armed Forces in the Partnership for Peace Program, for the establishment of the Rapid Reaction Force, as well as for other actions approved by law. According to historical data, the ME for Romania in 2009 recorded a significant decrease compared to 2008, but still higher than in the previous period 2005–2007. At that time, the North Atlantic Treaty Organization (NATO) data argued that at the US level, military spending was twice as high as the total expenditure of all Member States.

Romania's military costs exceeded for the first time the $3 billion thresholds in 2016, more than the Hungarian and Czech Republic's cumulative military budgets, and the amounts allocated to Greece for this purpose. Additionally, this year, the executive power decided that equipment purchases or repairs of the fighting technique could also be funded from the government's reserve fund, which would make it difficult to calculate Romania's actual military spending. Thus, after many decades, 2016 was the first year in which Romania's defense budget exceeded that of Greece, a country where the gross domestic product (GDP) was higher than in Romania.

In 2016, the largest defensive budgets in the eastern region of the continent, without taking into account Russia and Turkey, were allocated by Poland, Romania, Greece, Ukraine, the Czech Republic and Hungary, with the remaining states in the region having military budgets under one billion dollars. In 2016, from a logistical point of view, we can remember that Romania was distinguished by ensuring air security, one of the country's major defense vulnerabilities, receiving the first six aircraft F16 A/B Block 15 US Airplanes upgraded to M 5.2 of the 12th Squadron, which were purchased from Portugal, and three were supplied by the United States and continued to improve the fleet through various administrative programs, the budget spending on military spending rising to the detriment of other more productive sectors. From the point of view of the security and defense of the state, Romania was involved in the CSDP (Common Security and Common Security Policy) from its incipient stages, building its profile being an active participant in this structure, both on the political dimension, dedicated supporting the interests identified by the Member States as common to the security and defense and operational ones, contributing to the many civilian missions and military crisis management operations of the EU. Romania is a major member of important CSDP structures: The EU Satellite Center in Torrejon (Spain), the European Security Studies Institute in Paris (France) or the EDA European Defense Agency in Brussels. In this context, our country is involved in several capacity development programs: Capacity Development Plan, EU/EU Battlegroups, BGS. On the military side, Romania contributes to operations such as EUFOR Althea in Bosnia and Herzegovina, EUTM Somalia, EUNAVFOR Atalanta, EUTM RCA—Central African Republic, EUNAVFOR MED Sophia.

Romania's priorities in the field of national defense policy are outlined by three vectors, namely the development of the EU defense capabilities, the common security and defense policy in complementarity with NATO, based on the declaration in the field adopted at the NATO Summit of Warsaw and the promotion of priorities in the perspective of Romania's holding of the EU Council's bi-annual presidency in 2019 and the revival of the national defense industry by 2026. The above-mentioned vectors are found in concrete actions targeted by the Ministry of National Defense for the period 2015–2019 with reference, in particular, to the National Defense Strategy of the country becoming a strong Romania in Europe and the world, establishing national security and defense objectives, Romania's NATO and EU profile, strengthening the strategic partnership with the US, ensuring security in the Black Sea region, deepening cooperation with neighboring and eastern flank countries, enhancing regional cooperation, including in defense and promotion of political and economic security in regions of strategic relevance for Romania.

Security and defense are in a cause-effect relationship with growth and must be directly proportional to innovation, requiring major investment in defense. Romania is now welcoming the idea of a European Union of Defense, with the Member States being able to enjoy without discrimination the same benefits of defense unions, which are functional, equitable, accessible and transparent, promoting technological innovation, facilitating cross-border access for enterprises small and medium-sized resources and associated costs. To cope with security risks, cohesion and consensus at EU level are needed on the issues facing Romania, especially in the face of terrorist threats. By virtue of these considerations, Romania supports the correlation of the projects under the European Defense Fund with those to be planned through permanent structural cooperation (PESCO), the role of the European Defense Agency in both cases being major.

The ambitious EU and hence of Romania's "Shared Security and Defense" scenario is based on the pooling by the Member States of some financial and operational resources, such as increased solidarity. In the defense field, the EU becoming more involved in Europe's protection inside and outside its borders. The EU will take a more prominent role in areas such as strengthening the security dimension and defending internal EU policies, cybersecurity, border protection and the fight against terrorism. The most reasoned scenario, entitled "Common Security and Defense", refers to the progressive definition of a Union common defense policy that would lead to a common defense under Article 42 of the EU Treaty as stated in the Extract of the "Texts Adopted" document, 21–24 November 2016, European Parliament. The EU will be able to carry out high-level security and defense operations, backed by a high degree of integration of the Member States' defense forces.

The 21st century is the era in which each person's security is one of the most essential needs. The Sustainable Development Goals (SDGs) ask to promote peaceful societies for sustainable development, provide access to justice for all citizens. To ensure internal and external security for citizens is the mission of a state. Therefore, politicians have to decide how much money they allocate to the defense sector. This article, therefore, aims to study the existence of the causal relationship between military expenditures and sustainable economic development in Romania. Moreover, we contribute to the existing literature through the updated recently updated data set and concentrating on the Eastern European country—Romania, who joined the EU and NATO. The policy changes from EU, NATO and the own government may affect the causal relationship between these two variables, that is, structural changes will lead to inaccurate results. Furthermore, different from the Western European countries, which are mainly typical military economies, Romania is a transition economy and hence may possess distinctive characteristics. Furthermore, we innovatively employ the bootstrap rolling-window method to estimate the causality. This method is distinctive from most conventional mathematical approaches, which cannot identify the sub-sample relationships between the time series and cannot reveal how such relationships vary over time. This issue can be solved by allowing the causal relationship between ME and the GDP to be time-varying rather than using full-sample data that assume the single causality holds in every period. In consequence, the empirical results highlight that defense spending will affect economic growth positively or negatively through different channels in the 1980–2018 sample period. Accordingly, policymakers should make reasonable military expenditure plans to prevent hindering sustainable economic growth.

The following study is structured as the second part mentions the literature review. The third part analyzes the theoretical foundation. The methodology is described in the fourth part, and in the fifth part being presented the data and empirical results. The last section of the study represents the conclusions and discussion.

2. Literature Review

Empirical investigations provide evidence that causality relationships between ME and GDP are inconsistent, the results are not unitary, some negative, some highlight positive correlations, others insignificant.

In the numerous research papers, a large number of methods are identified that demonstrate that ME can affect GDP (LaCivita and Frederikesen [4]). The main factor was the overcoming of the defense budget in some states compared to the budgets allocated in other fields of activity, more productive and profit-making. Traditional arts versus butter suggests that defense spending impedes GDP by eliminating investment and consumption. In specific, there is a negative 'trade-off' between defense and education expenditures, which is not conducive to sustainable development.

The arguments made by the researchers have shown that ME prevents long-term sustainable development in some less developed countries, due to unfunded investments, inflationary pressures and the reduction of the allocation of resources in the field of investments and in other areas generating more productive jobs in order to increase the standard of living. Kollias [5] find that all these channels through which the defense sector can influence—the promotion or the delay—the increase presupposes that such expenditures are in a causal relationship with the GDP. The empirical evidence provided by Lebovic [6], Mintz [7], Scheetz [8], Ward [9], Asseery [10], Dunne [11], Dunne et al. [12], Mylonidis [13], and Pieroni [14] support the argument that military spending prevents GDP in terms of investment, health, education, and infrastructure improvements, which is not following the requirements of SDGs. Eryigit [15] also underlines the negative effect of the ME on GDP in Turkey, based on the cointegration method that allows structural breaks. Hou [16] indicates a negative correlation between ME and GDP in more developed countries. Other reports about this are available from Karagol [17], Karagol [18], Mylonidis [13], Smith [19], Abu [20]. Karadam et al. [21] attempt to analyze the use of nonlinear panels to examine the effects of ME on GDP for the countries of the Middle East. The conclusions of the analyzes show that the impact of ME on GDP is not linear and even inconclusive in some cases. The results also indicate that the increase of ME and arms imports of a state has a major influence and a negative impact on GDP.

There are also some cases where research shows that ME stimulates GDP and has a positive influence on economic well-being. For instance, Benoit [22] suggests that ME positively impacts economic development, and the impact of ME on GDP has been extensively examined in this respect. Deger [23] argues that military and security spending disproportionately hinders economic efficiency, although it otherwise ensures peace, stability, and national suffocation, which, in turn, are necessary for economic progress. Lee and Chang [24] study the correlation between ME and GDP in Taiwan over a longer period by analyzing multivariate co-aggregation, it demonstrates the ME can boost economic performance significantly. Wijeweera and Webb [25] conclude that an analysis performed based on aggregate demand is the most appropriate method to analyze the correlation between the variables studied for the case in Sri Lanka. Following their studies, it was concluded that there could be an increase in GDP in Sri Lanka if the budgetary allocations of the authorities were different and the allocations to the production and investment sectors would be higher. Their article concludes that some positive economic results depend entirely on the political decisions of the state. Sheikh [26] find the positive link between military spending and GDP apply the GMM method. Inequality is proving to be negatively associated with GDP. Daddi [27] investigate the impact of ME on GDP in Italy, the results showed that there is a military burden that has significant effects on GDP, promoting "peacekeeping" productivity and humanitarian missions that reduce insecurity from the external threat and implicitly of the investments and the jobs. García et al. [28] analyze the influence of the allocation of the defense budget in Spain and its autonomous agencies and mention the effects of the cross-sectoral effects on the rest of the economy. The results show that the activity in the military sector and the activity of the agencies generated 1.2% of the GDP of the country and 1.7% of the total employment during 2010. Su et al. [29] also demonstrate the existence of a positive bidirectional causal relationship between GDP and ME in their studies, which suggests the interdependence between variables and in China.

In the context of Eastern European countries, ME was regarded as an effective factor for the arms race in these countries during the Cold War. Since the early 1990s, these countries have developed different economic and political structures, including participation in EU membership, democracy, political and economic transformation. However, few studies conducted to examine the relationship between ME and economic growth in this region. Topcu and Arasend [30] find the end of the Cold War had a significant negative impact on defense spending in east-European countries. Topcu and Aras [31] further indicate that there is no long-term relationship between ME and GDP and there exists a unidirectional causality running from economic growth to ME in central and Eastern countries.

More comprehensively, some literature indicates that there is a heterogeneous correlation between ME and GDP among countries. Churchill and Yew [32] use the meta-analysis to prove that the positive effects of ME on growth are more pronounced for developed countries than less-developed countries. Topcu and Arasend [30] even state that the correlation is not uniformed across all EU members. Desli and Gkoulgkoutsika [33] employ the dynamic common correlated effects estimator to test the effect of ME on GDP. Overall, the worldwide effect of military spending on economic growth over the period 1960–2017 appears to be negative owing to the cold war and is especially evident for the NATO countries. However, at the country-specific level, some economies consistently benefit or suffer from military spending varying over different time periods.

According to research studies, the researchers mentioned that there is a clear relationship between GDP and GDP. However, there are still scholars who imply that there is no significant causality between the two variables, particularly when the ME is low [34,35]. Overall, it are still ambiguities regarding the interaction between ME and sustainable economic performance. Additionally, most of the studies assume the linear nexus, ignoring time-varying features of time series. Moreover, previous literature tends to focus on developed countries. The regions of Eastern Europe are prone to be less studied. Lastly, it is obvious that the unidirectional effect from ME on GDP has been widely investigated. However, the bi-directional causality regarding this topic is inconclusive.

3. Theoretical Foundation

ME affects the economic growth of a country in two ways: Demand-side effect and supply-side effect [36]. The demand-side effect implies that ME increases the aggregate demand, which stimulates the employment rate and economic progress. While from the perspective of supply-side, ME will exert complicated effects on the economy. Specifically, on the one hand, based on opportunity cost theory, if ME is in a large share of the government budget, then this will crowd out the investment and the capital from the civilian economic activities due to the limited resources. Moreover, an increase in this spending would divert domestic credit from civilian production and raises the cost of these credits for the private sector. As a result, economic growth may deteriorate [37]. On the other hand, the supply-side effect denotes that infrastructure improvement and the related consumption effects through which the ME may indirectly contribute to economic development and technological innovation by the development of the public infrastructure such as roads, bridges, railway lines, airports, canals, dams, etc. These projects are especially helpful in the less developed countries and remote areas where civilian governments have fewer resources and incentives to invest in. However, military goods generated by defense spending are mainly nonproductive, which implies that defense spending induces more demand rather than more supply, resulting in inflation [38]. Extensive inflation is disadvantageous to the sustainable economic development. In addition, adequately sized, trained, and equipped force is necessary for national security to dissuade and even defeat enemies. In this view, if military security is compromised, then economic stability appears vulnerable.

On the contrary, economic development would have either a positive or negative effect on ME. Economic growth could provide more funds and resources for ME and public service. However, the growth in an economy does not necessarily mean an increase in ME. The national military strategic plans are different in every country, depending on the external and internal environments. Thus, the nexus between economic growth and ME varies across countries. If a country is trying to protect the national security and wealth from external threats, such as terrorism, transnational crime, ethnic separatist, etc., then a causality that runs from economic growth to ME may hold. Otherwise, economic development may not necessarily promote ME.

4. Methodology

4.1. Bootstrap Full-Sample Causality Test

In our study, we relied on the complete Granger non-causality test, namely the bivariate autoregressive vector (VAR). Given the sensitivity of this method of analysis for a certain period, we set out to use the variables for a given period of time, so that the results express a causality between ME and GDP, not a constant causal relationship [39].

In the VAR model, the time series data are assumed to be stationary in the Granger causality test. Therefore, according to the statistical data, including the likelihood ratio (LR), the Wald test and the Lagrange multiplier (LM) tests will not be in the definitive estimation in VAR models. The modified test is proposed to estimate the processing variables of the augmented VAR model, applying when the time series is I (1) [40,41].

RB and *LR* can be explained by the VAR framework for two variables as follows:

$$Y_t = \phi_0 + \phi_1 Y_{t-1} + \ldots\ldots + \phi_p Y_{t-p} + \varepsilon_t,\ t = 1, 2, \ldots, T \tag{1}$$

By splitting y_t into two sub-vectors, $y_t = (y_{1t}, y_{2t})'$, thus the above equation can be rewritten as follows:

$$\begin{bmatrix} GDP_{1t} \\ ME_{2t} \end{bmatrix} = \begin{bmatrix} \phi_{10} \\ \phi_{20} \end{bmatrix} + \begin{bmatrix} \phi_{11}(L)\phi_{12}(L) \\ \phi_{21}(L)\phi_{22}(L) \end{bmatrix} \begin{bmatrix} GDP_{1t} \\ ME_{2t} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \tag{2}$$

where $\phi_{ij}(L) = \sum_{k=1}^{p+1} \phi_{ij,k} L^k$, $i, j = 1, 2$ and L is the lag operator defined as $L^k x_t = x_{t-k}$.

Starting with Equation (2), we analyze the causality hypothesis between ME and GDP, taking into account certain restrictions, such as for $k = 1, 2, \ldots, p$, we consider that ME does not produce effects. Similarly, the inverse causal hypothesis is tested for $k = 1, 2, \ldots, p$. Following the above analysis, we mention that it is not conclusive whether ME has an impact on GDP and vice versa.

4.2. Parameter Stability Test

If the Granger test is not conclusive, the final results can be considered null, and the causal correlations are considered unstable [39]. Therefore, before using the rolling window estimation, the parameter constant over a short period of time was tested using Mean-F, Exp-F and Sup-F tests [42] and the long-term parameter stability of the VAR model above, applying the Lc Test of Nyblom [43] and Hansen [44]. Considering these data, when the basic variables have been cointegrated, the VAR model at the first analysis may be wrongly predicted, unless the error correction is allowed. For clearer and more precise conclusions, the fully modified Ordinary Least Squares estimator (FM-OLS) proposed by Phillips [45] and Hansen [44] was used. In these analyzes, testing the constant parameters in the VAR model is compared with any possible alternative a unique structural change.

4.3. Rolling-Window Granger Estimation

In this analysis, the test used is adopted based on a modified estimation of the bootstrap [46]. Thus the complete sample is transformed into a sequence of variables Tl, i.e., τ-l + 1, τ-l, ..., *T* for τ = l, l + 1, ..., *T*. Non-test. Modified causality based on RB is then estimated in each sub-sample, but not in the complete sample. By calculating the *p*-values of the bootstrap of the observed LR statistics that are carried out through *T*-l sub-samples, some changes can be observed between ME and GDP.

The causal relation index is observed by calculating the effect value, and the GDP on the impact on the ME is mentioned as the average of all derived bootstrap estimates from the formula, with $N_b^{-1}\sum_{N-1}^{p}\hat{\phi}^*_{21,k}$ with N_b the number of bootstrap repetitions. Similarly, the impact of MEs on GDP is measured by the formula $N_b^{-1}\sum_{N-1}^{p}\hat{\phi}^*_{12,k}$. Both $\hat{\phi}^*_{21,k}$ and $\hat{\phi}^*_{12,k}$ are bootstrap estimates from the VAR models in Equation (2). The 90% confidence intervals are provided, in which the lower and upper bounds are the same as the 5th and 95th quantiles of $\hat{\phi}^*_{21,k}$ and $\hat{\phi}^*_{12,k}$ respectively [46].

5. Data and Empirical Results

In this study, we base annual data from 1980 to 2018 to examine the nexus between ME and GDP in Romania. The dataset of GDP is present in current prices (purchasing power parity, billions of international dollars), which is sourced from the International Monetary Fund (IMF). The ME data, in millions of US dollars, current prices, converted at the exchange rate for the given year, is from SIPRI Arms Industry Database. The trend of these two variables is shown in Figure 1.

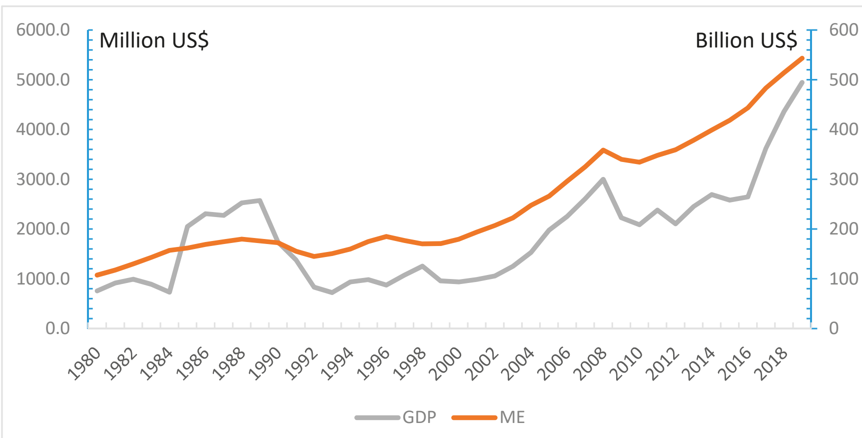

Figure 1. The trend of ME and GDP.

To test the data stationarity test, we performed the Augmented Dickey–Fuller test (ADF, 1979), the Phillips–Perron test (PP, 1988) and the Kwiatkowski Phillips Schmidt Shin test (KPSS, 1992). Table 1 mentioned the conclusions in which it was found that both ME and GDP are stationary processes in the first differences, which suggests that both are a process I (1).

Table 1. Unit root tests.

Series		ADF	PP	KPSS
ME	Level	−1.345 (0)	−1.486 (2)	0.399 (4) ***
	1st difference	−5.098 (0) ***	−5.067 (2) ***	0.088 (2)
GDP	Level	−0.019 (1)	−0.155 (2)	0.683 (5) **
	1st difference	−2.839 (0) *	−2.632 (5) *	0.125 (2)

Source: Authors' calculations. Notes: *, ** and *** denote significance at 10, 5, and 1 percent, respectively.

We choose the optimal lag-lengths of ME and GDP 2 based on the Schwarz Criterion (SC). Therefore, the next Table 2 shows the full-sample causality results. We can infer that there is a relevant relation running from ME to GDP while GDP has no significant impact on ME over the full-sample perspective. This finding is basically consistent with Braşoveanu [47].

Taking into account the above, we argue that the estimation of a complete causality neglects the unknown structural changes. The structural changes in the ME and the GDP consequently have unstable and meaningless causal relationships of the analyzed sample. Therefore, we use Sup-F, Mean-F, Exp-F, and Lc tests to investigate whether this result is supported by the constancy of the parameters, and the results are presented in Table 3. The results suggest that there is a strong change once in ME, GDP and VAR system at 1% level. The conclusion is also rejected considering the *p* values of the second and third lines, which indicates equations from ME, GDP and VAR system could evolve gradually. The results of the Lc test do not demonstrate the consistency of the parameters for the VAR model.

Table 2. Full-sample Granger-causality tests.

Tests	H_0: *ME* Does Not Granger Cause *GDP*		H_0: *GDP* Does Not Granger Cause *ME*	
	Statistics	*p*-Values	Statistics	*p*-Values
Bootstrap *LR* Test	0.312	0.530	6.923 ***	0.000

Source: Authors' calculations Notes: *** denotes significance at one percent.

Table 3. Stability tests.

	ME_ Equation		GDP_ Equation		*VAR _system*	
	Statistics	*p*-Value	Statistics	*p*-Value	Statistics	*p*-Value
Sup-F.	26.493 **	0.041	88.077 ***	0.000	34.250 ***	0.008
Mean-F.	18.522 *	0.069	28.435 ***	0.000	20.378 **	0.032
Exp-F.	6.843 *	0.097	39.119 ***	0.000	14.091 *	0.069
$L_c{}^b$					13.524 *	0.074

Source: Authors' calculations Notes: We calculate p-values using 10,000 bootstrap repetitions. *, ** and *** denote significance at 10, 5 and 1 percent, respectively.

We will take into account the results obtained from the estimation of the model based on the rolling window, which gives us a greater accuracy of the data. Considering the null hypothesis, we concluded that there was no causal relationship between ME and GDP. According to Pesaran and Timmerman [48], we choose a period of 15 years in adopting the estimation of the rolling window so that we have greater clarity and accuracy of the data. Moreover, different time periods will be used, such as 18–20-year tests and the impact of ME on GDP is estimated and vice versa, the results coinciding with those following the 15-year analysis. From this, we deduce that the conclusions are the same regardless of the period. Figure 2 shows the starting system of p values of LR statistics using GDP as dependent variable in Romania. Figure 3 shows the estimates of the bootstrap test for the sum of the running coefficient, measuring the impact of ME on GDP. Exceeding the zero value of the prominent line represents a positive impact, otherwise, the effect is negative.

Specifically, the null hypothesis is rejected from 1996 to 2006. Figure 3 indicates that in 1996–1999 and 2002–2004, the ME exerted a negative effect on the GDP, while in the sample of 1999–2002 and 2004–2006, the relationship between the two series was positive. From 1996 to 1999, the economy in Romania experienced a continued three-year decline [49]. The decline has been largely accounted for the severe reduction in fixed investment and private consumption. The Kosovo crisis had a modest impact on increasing ME. However, parliament still approved a tough austerity budget, including much higher excise taxes on fuels and property taxes. In this situation, military spending may adversely affect investments, savings, human capital, infrastructure programs, and market-oriented technological innovation. This verifies the ME can impede sustainable economic development by crowding-out private investment.

Starting with 1999, the decrease in purchasing power and the deterioration of the economic well-being in the country, led to several demonstrations among the population in the country. One of these was triggered by the miners' dissatisfaction with the economic situation and the employment prospects in the Jiu Valley, the unemployment rate [50]. The government increases ME can generate economic benefits because it provides security, which promotes a stable social and economic environment. It also contributes to improving the educational level of the workers and may act as a stabilizing influence in society by expenditure on defense training. As Brașoveanu [47] has mentioned, the war, corruption, security and defense policy of a state strongly impact the sustainable development of a society. At that time, Romania made all the necessary steps to join the EU. On 18 June 1999, a new national security and security strategy was adopted by the Supreme Defense Council of the country where the idea of EU membership was one of the main priorities for Romania. Increasing the ME shows the improvement of comprehensive national power, which is prone to be accepted by the EU. Overall, the rise in ME in this period (1999–2002) stimulated economic development.

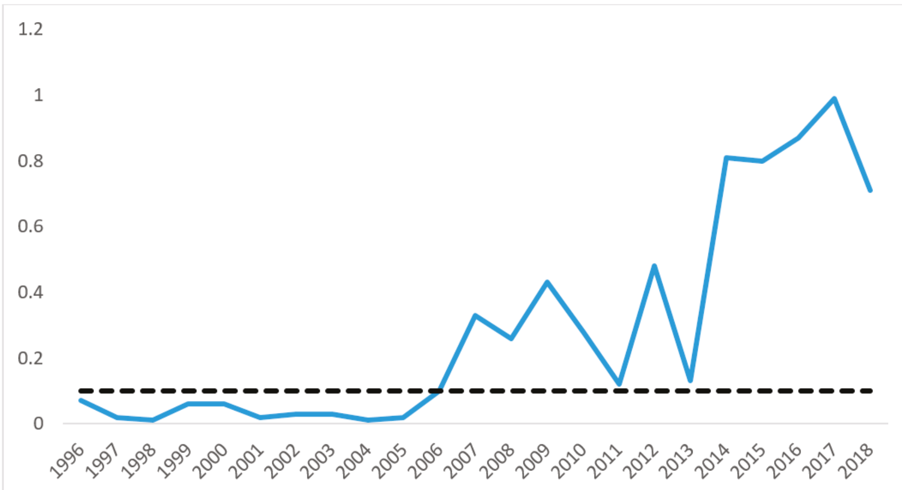

Figure 2. ME does not Granger cause GDP.

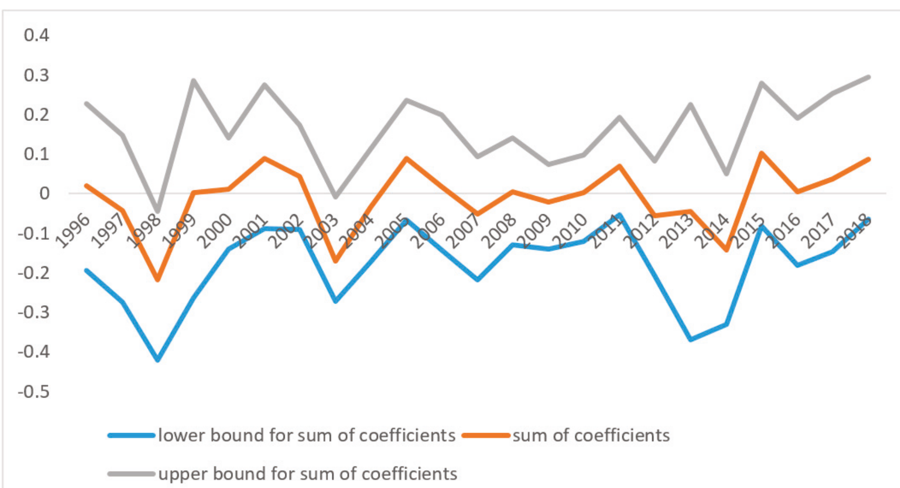

Figure 3. Bootstrap estimates of the sum of the rolling window coefficients for the impact of ME on GDP.

The causality from ME to GDP was negative in 2002–2004. Having inherited Soviet-era equipment, Romania could postpone major military purchases. Combined with reductions in defense budgets, Romania has reduced spending on military maintenance, operations and training for the majority of the armed forces. For example, Romanian Chief-of-Staff General acknowledges that 70 percent of Romania's air force pilots were not operational due to budgetary constraints [51]. Since mid-2000, GDP has remained robust, inflation and unemployment have been steadily declining, and it is imperative to revitalize the economy in Romania [52].

Romania became a member of NATO in 2004. The Land Forces have overhauled their equipment, which participates in a peacekeeping mission in Afghanistan and Iraq, together with the other NATO countries. They are forced to develop more professional elements within their armed forces that are more suited to deployment abroad in multinational military operations, Cottey et al. [51]. Furthermore, in order to complete preparations for EU accession, Romania makes efforts to improve legitimation and regulation on the military. ME may be considered a tool of fiscal policy and can be increased to stimulate demand. Moreover, the trade of EU exports to Romania has significantly increased [52]. Therefore, we can conclude that Romania achieves expansion of aggregate demand and exports through the fiscal policy of ME. The accession to NATO and planning to join the EU also provide a more open and stable economic environment. This contributes to the positive relationship between ME and GDP in 2004–2006.

In Figure 4, we observe that the null hypothesis is not considered rejected for all the analyzed periods, which means that the GDP has no significant effects on the ME in Romania. ME can be regarded not necessarily as a purely economic problem, but rather as a strategic political, social, economic and psychological effect [53]. In such studies, Gleditsch and Njølstad [54], Intriljgator [55] have also mentioned such correlations between the two variables and strategies. Romania has done its utmost to join NATO and the EU at the end of the Cold War, thus supporting US operations in Iraq and Afghanistan [56].

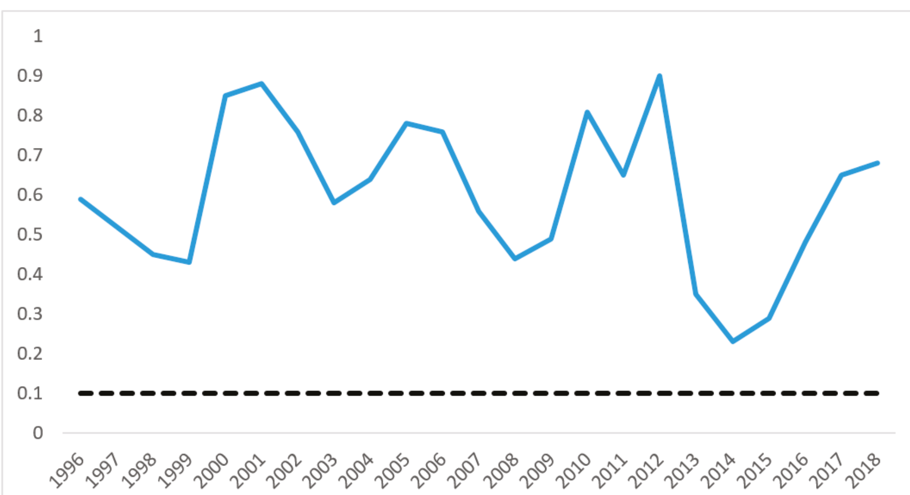

Figure 4. The null that GDP does not Granger cause ME.

6. Conclusions and Discussion

In this paper, we have tried to investigate the relationship between ME and GDP in Romania since 1980. In order to obtain conclusive results on the correlation between the two variables, the Granger non-causality test with full sample and rolling window estimation was used in the analysis. The results show that the ME would have both positive and negative effect on GDP in Romania. In specific, the impact of ME on GDP was negative during 1996–1999 and 2002–2004. It can be inferred that during the periods of turbulence in neighboring countries, the increase of ME would crow out private investment and consume, which is harmful to GDP. From 1999 to 2002 and 2004–2006, GDP was positively associated with ME. We can conclude that, in the period of domestic turmoil and participation in NATO, rising ME contributes to stabilize the domestic environment and thus stimulate the sustainable development of the economy. This finding is in accordance with the Dunne et al. [11], who propose that the positive effect of ME on GDP is particularly significant in less developed countries, where war and turmoil are major obstacles to sustainable development. In specific, raising ME can protect society from violence and invasion of other countries or groups. Moreover, training in the armed forces can improve the quality of human capital, which makes them more competitive when they are employed. Therefore, the improvement of the employment rate is associated with higher economic output. However, the empirical result indicates that GDP does not have a significant effect on ME, which is contrary to the result of Su et al. [29]. It can be attributed that the ME in Romania is lack of independence, which would be affected by the policy of NATO, EU and US.

Therefore, the implication for the policymakers can be summarized as: The government should adjust its ME according to the military or political environment at home and abroad to promote economic development. Excessive ME in peacetime will squeeze out private investment and civilian resources, which is harmful to sustainable development. While in the period of chaos, increasing ME can maintain a safe social order and increase economic output. Moreover, mastering the independence of military policy should be considered by authorities. The analysis proposal could contribute both to the decision-making at the governmental level and the allocation of military sector funds in the current context, as well as to the foundation of a political decision-making process aimed at increasing the efficiency of the expenditures by the executive power of a state.

Considering the nonlinear nexus between ME and sustainable economic development, future research can further explore if there exists threshold value, before and after which, ME will have a different effect on output. In addition, the limitation of this article is that the conclusion is confined to the context of Romania, hence, it cannot be extended to the general situation. A future study could provide a more general analysis of this topic.

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sustainability

Article

Government Intervention and Automobile Industry Structure: Theory and Evidence from China

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Abstract: The development of the automobile maintenance industry less developed to satisfy the increasing demand for automobile maintenance service as the automobile manufacturing industry increased rapidly in China. This is not conducive to the sustainable development of the automobile industry. Besides the factors of market behavior that can affect the automobile industry structure, like an investment, operation structure or economic development stage, the structure is also influenced by government intervention. We investigated the unbalanced development of automobile structure from the perspective of government incentives, and provide a logical framework for analyzing the industrial policies on the automobile industry. We first established a two-sector theoretical model with government intervention, and we found that the governments' GDP incentive induced the biased intervention policy. More preferential policies are given to enterprises of automobile manufacturing industries as they contribute more to intermediate goods and capital. The greater the government's GDP incentive, the more biased the intervention will be. Then we test the differential impact of GDP incentive on tax avoidance of the two kinds of firms empirically. The empirical results show that GDP incentive of the government induced more preferential treatment to automobile manufacturing enterprises, and thus, increased their tax avoidance. This phenomenon is more significant in SOEs, larger firms and firms belong to local governments. Understanding the incentive and implementation of industrial policy can help us know the evolution of automobile industrial structure better, and then improve industrial policy better to promote the transformation and upgrading of automobile industrial structure.

Keywords: automobile manufacturing; automobile maintenance; government incentive; government intervention; tax avoidance

1. Introduction

The economic development process of various countries in the world shows that vehicle ownership gradually increases with the development of economy, especially GDP per capita [1]. Although the automobile manufacturing industry increased rapidly in China, automobile maintenance industry less developed compared with developed countries and has not received enough attention [2]. The auto care industry is developing quickly in the United States in recent years. According to the data of Auto Care Association, the number of people employed in the auto care industry is 4.6 million, and the number of automobiles in operation is 278.6 million in early 2018, and the average annual sales value of auto care industry is now 381 billion. Chain operation mode, which has been developed rapidly in

30 years, was adopted in automobile after-sales service companies in the United States [3]. The supply chain not only includes the automobile manufacturer, but also the after-sales service market of auto parts supply and an integrated maintenance service provider [4]. This pattern not only makes the price of service more transparent, but also can integrate the auto parts resources of each brand and break the vertical monopoly [5].

The situation of auto care is less encouraging in China. According to the China Automotive Aftermarket Blue Book (2013–2017) [6], the average annual growth rate of China's automotive aftermarket will exceed 30% in the future, and the market size is expected to exceed one trillion Yuan after 2018. According to the news of research and markets [7], Chinese automotive aftermarket revenue is expected to record a compound annual growth rate of 7.7%, increasing from $290.44 billion in 2017 to $523.80 billion in 2025. During this period, the vehicles in operation for Chinese passenger vehicles are expected to grow from 185 million units to 401.7 million units. However, the development of automotive aftermarket is not sufficient to satisfy the increasing demand for automobile maintenance service in China. 4S stores (store for automobile sale, spare parts, service, and survey) is the leading form of after-sales service market in China [8], and it needs a large investment to develop well. However, many of them with limited sales in the market are unable to cover their costs with intense competition and the gradual increase of investment [6]. The development of domestic automobile maintenance enterprises in the initial stage will also be impacted by the external competitive environment because foreign enterprises bring more new technologies and new business models when they enter the market.

The ignorance of maintenance and service will have a negative impact on the automobile industry, which is not conducive to the sustainable development of the automobile industry. Firstly, the quality and development of auto maintenance industry will affect customer loyalty, which has been paid attention by the American automobile industry [9,10]. There are a large number of single stores and brand chains providing high-quality maintenance and customer service in the United States, and automobile service is insurance of financial and strategic advantages to help the company survive in this highly competitive industry [11,12]. Secondly, from the perspective of market sustainability, automobile maintenance will satisfy and promote the development of new kinds of vehicles. The market share of shared vehicles, electric vehicles and autonomous driving is increasing, and maintenance process of these kinds of vehicles is different with the conventional ones, for example, the annual maintenance cost of vehicles will increase as the annual mileage of shared cars increases. In addition, customers' expectations and requirements on the automotive maintenance industry are also constantly rising with the development of economy, science and technology. So it is necessary for the automotive service industry to constantly improve its development mode and introduce new technologies, which presents challenges and opportunities for the whole industry. Thirdly, lack of attention to maintenance will make China's maintenance industry lag behind in the Internet era. Nowadays, the popularization of the internet brought business opportunities for shopping and O2O (Online to Offline) service industry [13,14], and the automobile maintenance industry should also grasp the opportunities of the internet era and realize the transition of traditional industries. Finally, from the perspective of sustainable regional growth, the diversity of aftermarket growth in different regions reflects the market maturity to a large extent. The growth rate of emerging markets will exceed that of mature markets, and the rapid growth of China's vehicle ownership will drive the share of Asia in the global aftermarket. According to the experience of North American and European markets, the more developed the post-market is, the higher the degree of integration in the transaction level of the industry is. Therefore, it is of great significance to understand the reasons of the slow development of the automobile maintenance industry in China and to make the automobile maintenance and automobile manufacturing industry develop and integrate in a balanced way. What's more, automobile maintenance industry is an important part of the service industry, which is critical to national competitiveness and industrial structure [15,16]. The appropriate industrial structure adjustment will promote economic growth because of the "structure bonus" brought by the movement of production factors in different sectors [17,18], especially for developing countries [19,20]. Although it's right to develop the automobile manufacturing industry more than the automobile maintenance industry in the initial phase of the development of the automotive industry, China should pay more attention to the balanced development of the two industries after passing this first phase.

As an important part of the service industry, there are some reasons why China's automobile maintenance industry has not developed enough. Firstly, the imperfect investment and financing environment lead to the fact that most maintenance firms lack external financial support and the investment is far away from enough for development. Secondly, China is still in early stage of vehicle ownership development process, and the ratio of vehicle ownership per thousand people is only 172 according to the data of World Road Statistics dataset (WRS) [21]. This number is far away from saturation level, 807, according to Dargay and Sommer [22], and there is still a lot of space for the automobile industry to develop. Thirdly, some researchers believe customer recognition is the most serious barrier at present in the external environment [9,10]. Most of China's automobile maintenance businesses do not pay sufficient attention to information resources, and they have not yet formed a unique business model that is closely connected with the market [6]. What's more, some market factors that affect industrial structures, such as the change of demand, technology improvement, endowment and trade [23–26], can affect the automobile maintenance industry as well. According to the theory of development economics, industrial structure changes with economic development; however, the industrial structure varies in countries that share similar development stages. Although the economy grows rapidly, industry accounts for the largest share of GDP for years until 2015 in China, and the ratio of the service industry is still far away from that of developed countries, even some developing countries. According to the data of Statistical Yearbook of the World [27], service sector accounts 70.9% on average all over the world, 74.3% in the high-income countries in 2010, and 55.6% in middle income countries, 55.5% in low income countries, while, it is only 44.6% in China. So, are there any other reasons that can explain these facts?

Since the marketization degree in China is not very high, and the government plays a great role in the economy, we think that government intervention is another important factor that can affect industry structure in China. Some researchers proposed that in early stage of economic development, industrial policies may accelerate the industrial structural change and improve resource allocation [28,29]. It is also found that the industrial policy can enhance competition among enterprises and promote the growth of enterprises [30]. Local governments are important participants in promoting China's economic development in the process of China's industrial transformation. Therefore, in addition to the natural evolution of market behavior, the industrial structure is also subject to government intervention. We try to explain the problem from the perspective of government incentives and provide a logical framework for analyzing the industrial structure. Some researchers proposed incentives for self-interest and for electoral success in public choice theory [31,32]. Some researchers believe that local governments have fiscal revenues, GDP and promotion incentives under the centralized political and decentralized fiscal institute in China [33]. Thus, many stimulus measures are adopted to boost economies [34,35] and then affected industrial structure [36]. However, the mechanism of the process has not been systematically studied because existing researches pay more attention to the evaluation of policy effects. Therefore, we try to explain the mechanism of the impact of the government incentives on automobile industrial structure.

The government can use different kinds of interventions, which take many forms, including explicit subsidies and bonus, such as research and development subsidies [37–39], but more of them are invisible, such as granting loan guarantees and loan preferences to enterprises to reduce their capital costs and financing constraints [40]. Another example is effective tax rates, which can be affected by tax preference and taxation intensity so that a firm's tax burden can be affected as well, although the tax rate is legal [41,42]. This kind of intervention changes with government incentives and varies in different enterprises.

We found both theoretically and empirically that the governments' GDP incentive induced the biased intervention policy on automobile manufacturing and maintenance industries. In the theoretical model, the government's GDP incentive leads to the more patience of the government than the consumer. The government doesn't care about current consumption, but care about whether enough investment and capital can be generated to promote economic growth. Thus, the enterprises of different industries that have different contributions to investment and capital accumulation will inevitably be subject to different government intervention. More preferential subsidies are given to automobile manufacturing firm whose production serve as intermediate goods and capital. Moreover, the greater the government's GDP incentive, the more biased the intervention will be. Then we test the differential impacts of GDP incentive on tax avoidance of the two kinds of firms empirically. The empirical results show that the government GDP incentive induced more preferential treatment to automobile manufacturing enterprises, and thus, increased their tax evasion compared with automobile maintenance firms.

Our study makes several contributions to the existing literature. First, we explained why China's automobile manufacturing and maintenance industry is unbalanced from the perspective of government intervention and incentives. Some researchers analyzed government intervention instruments and their effects on economic variables, such as resource misallocation, total factor productivity and costs [43,44], but little literature involves the motivation of government policies. The literature on optimal policy [30–32], which adds government policy in the general equilibrium model are more about the fiscal policy, monetary policy or tax policy on consumption or capital; little is about industrial policy in different sectors. Therefore, we investigated the impact of government incentive on industrial policy and industry structure, and provide a framework to study the interaction of government and the market, which also applies to other countries. Second, the growth rate of GDP is converging from the perspective of the development economics [45], and since automobile industry has always been a pillar industry and in China, how to promote the automobile industry to develop in a balanced way is crucial to the sustainable development of the automobile industry and even the whole economy in the future. Although some researchers focus on sustainable district development [46], balanced development of industry structure is also important. Finally, the research about China's automobile industry mainly focus on the manufacturing industry currently, such as the prediction of vehicle ownership [1,47,48], study on life cycle cost of electric vehicle [49–52], the bottleneck in the development of electric vehicles [53–55], and research on the development and market scale of ride-hailing [56,57]. There is little literature on automobile maintenance industry; however, we need to fully understand the development of the automobile industry, including the maintenance industry to promote sustainable development.

The remainder of the paper is organized as follows. Section 2 presents the theoretical model and the development of the empirical hypothesis. Section 3 introduces the empirical model, variable definitions and data resources. Section 4 provides the empirical evidence. Section 5 provides several robustness checks to make sure our results are robust. Section 5 concludes and presents policy implications.

2. Theoretical Model and Empirical Hypothesis

We build a general equilibrium model with government incentive to investigate the effect of government intervention on the automobile industry. The general equilibrium model is widely used in modern economic research, especially the macroeconomic research about economic growth and industry structure [15,17,18,23–25]. Furthermore, the method of adding government policy in the general equilibrium model is usually used in the literature of optimal policy [30–32]. However, the literature is more about the fiscal policy, monetary policy or tax policy on consumption or capital, little is about industrial policy in different sectors. Thus, we also investigate the impact of government intervention on the automobile industry structure and its mechanism in this framework.

2.1. Theoretical Model

We assume that there are four participants in the economy: A representative consumer, two representative producers (i.e., one is an automobile manufacturing firm and the other is automobile maintenance firm) and a government. The market is completely competitive. The products of automobile manufacturing firm produce the finished automobile and auto parts, which can be formed capital in the economy, while the products or service of automobile maintenance firm can be consumed. Thus, the automobile manufacturing firm is more likely to be the upstream firm, and while the automobile maintenance firm is a downstream firm in the input-output production connections. Both of the two firms use capital and labor as input in the production process. We use subsidies as tools of government intervention and omit other intervention methods, such as tax rate. The subsidy rate for the automobile maintenance firm is denoted as s_1, and the subsidy rate for the automobile manufacture firm is denoted as s_2. The subsidy rates can be explained as the degree of government preferential, such as the relaxation of taxation [42]. The representative consumer is the providers of capital and labor. He provides capital and labor to producers and obtains rents and wage at the same time. Then the consumer uses the income to consume maintenance service to maximize utility for all periods of time. The utility maximization problem of the representative consumer can be expressed as:

$$\max_{c_t, K_{t+1}} u = \sum\nolimits_{\mathrm{t}=0}^{\infty} \beta^t u(c_t), \tag{1}$$

$$c_t + p_t(K_{t+1} - K_t + \delta K_t) \leq r_t K_t + w_t L - T_t, \tag{2}$$

here, u is the utility of the consumer, and $u(\cdot)$ is the utility function; c_t is the consumption of the consumer at time t; K_t is the capital stock at time t; L is the fixed labor supply per period; β is the discount rate, and δ is the depreciation rate of capital. Since there are only two products in the economy, we might as well set the price of the automobile maintenance service as one and the price of the automobile manufacturing production as p_t. The wages of the labor and the rent of capital are w_t and r_t, respectively. T_t is the lump-sum tax on consumer's income. We list the definition of each parameter in Table 1. If we set the Lagrangian multiplier of each period is λ_t, then the first-order condition of the consumer problem is:

$$u'(c_t) = \lambda_t, \tag{3}$$

$$\lambda_t p_t = \beta \lambda_{t+1}(p_{t+1} + r_{t+1} - \delta p_{t+1}). \tag{4}$$

Thus, the Euler Equation is obtained from Equations (3) and (4):

$$\frac{p_t}{r_{t+1} + (1-\delta)p_{t+1}} = \frac{\beta u'(c_{t+1})}{u'(c_t)}. \tag{5}$$

We assume that the production function of the automobile maintenance firm is $F_1(K_{1t}, L_{1t})$ and the production function of the automobile manufacturing firm is $F_2(K_{2t}, L_{2t})$. The production functions satisfy $F_{iK} > 0$, $F_{iL} > 0$, $F_{iKK} < 0$, $F_{iLL} < 0$, $F_{iKL} > 0$, $i = 1, 2$. The producers in each sector maximize the profits of each period:

$$\max_{K_{1t}, L_{1t}} \pi_1 = (1 + s_{1t})F_1(K_{1t}, L_{1t}) - w_t L_{1t} - r_t K_{1t}, \tag{6}$$

$$\max_{K_{2t}, L_{2t}} \pi_2 = p_t(1 + s_{2t})F_2(K_{2t}, L_{2t}) - w_t L_{2t} - r_t K_{2t}, \tag{7}$$

here, π_1 and π_2 represent the profit of automobile maintenance and manufacturing firms, respectively. Then the first-order conditions for the capital of the automobile maintenance firm and automobile manufacture firm are:

$$(1 + s_{1t})F_{1K} = r_t, \tag{8}$$

$$p_t(1 + s_{2t})F_{2K} = r_t, \tag{9}$$

here, we omit the subscript of time t of the production functions for briefness. The first-order conditions for labor of the automobile maintenance firm and automobile manufacture firm are:

$$(1 + s_{1t})F_{1L} = w_t, \tag{10}$$

$$p_t(1+s_{2t})F_{2L} = w_t. \tag{11}$$

We can know from Equations (8)–(11) that the government can influence the marginal production of labor and capital and then the production decisions of the firms, and then determine the capital flows between the two sectors by setting different subsidy rates. The government's subsidy expenditure comes from the lump-sum tax T_t imposed on consumers. Thus, the government's budget constraint is

$$T_t = s_{1t}F_1(K_{1t}, L_{1t}) + s_{2t}p_{2t}F_2(K_{2t}, L_{2t}). \tag{12}$$

As a social planner, the government's goal is certainly to maximize social welfare. However, the local governments have the promotion pressure in their career under the decentralization institute in China, so their goal is not entirely social welfare maximization, but the short-term GDP in their tenure. This incentive makes the government's time preference different from the consumer's in the market. The government is more willing to spend in the future and save currently to promote short-term growth of GDP. We set the government's short-term GDP incentive intensity to be a, which satisfies $1 < a < 1/\beta$. Then the discount rate of government is $a\beta$, and the larger the value of a, the greater the GDP incentive the government has. Therefore, the government's objective function is:

$$\max u_g = \sum\nolimits_{t=1}^{\infty} (a\beta)^t u(c_t), \tag{13}$$

here, u_g is the utility of the government. Given the subsidy rates s_{1t} and s_{2t} for the automobile maintenance firm and automobile manufacturing firm, the equilibrium of market can be determined by Equations (2), (5), (8)–(11) and the market clear conditions of the products of the two sectors, capital and labor, which is the Equations (14)–(17) below. The market clear condition for automobile maintenance service market is:

$$F_1(K_{1t}, L_{1t}) = c_t. \tag{14}$$

The market clear condition for automobile manufacturing market is:

$$F_2(K_{2t}, L_{2t}) = K_{1,t+1} + K_{2,t+1} - (1-\delta)(K_{1t} + K_{2t}). \tag{15}$$

The market clear condition for capital is:

$$K_{1t} + K_{2t} = K_t. \tag{16}$$

The market clear condition for labor is:

$$L_{1t} + L_{2t} = L. \tag{17}$$

This system expressed the dynamic equilibrium relationships for variables $\{c_t, K_{1t}, K_{2t}, K_t, L_{1t}, L_{2t}, p_t, r_t, w_t, T_t\}$. Then the government will choose the optimal subsidy rates s_{1t} and s_{2t} constrained by the market equilibrium conditions. We solve this problem with the steps below. Firstly, using the Euler Equation, which is Equation (5) and budget constraint, which is Equation (2), we change the consumer's budget constraint, which is Equation (2), of each period into budget constraint of all periods (please see the detail calculation in Appendix A part), which is:

$$\sum\nolimits_{t=0}^{\infty} \beta^t\, u'(c_t)(c_t - w_t L + T_t) = u'(c_0)[r_0 K_0 + p_0(1-\delta)K_0]. \tag{18}$$

We denote the right hand of Equation (18) as $A = u'(c_0)[r_0K_0 + p_0(1 - \delta)K_0]$, which is constant. Then the government will optimize Equation (13) conditioning on Equations (14)–(18), and choose the optimal value of variables $\{c_t, K_{1t}, K_{2t}, L_{1t}, L_{2t}\}$. The Lagrange function of this problem is:

$$\begin{aligned}\Gamma = &\sum_{t=0}^{\infty} (a\beta)^t \left\{ \begin{array}{l} u(c_t) + \eta_{1t}[F_1(K_{1t}, L_{1t}) - c_t] \\ +\eta_{2t}[F_2(K_{2t}, L_{2t}) - K_{1t+1} - K_{2t+1} + (1-\delta)(K_{1t} + K_{2t})] \\ +\eta_{3t}[L - L_{1t} - L_{2t}] \end{array} \right\}, \\ &+ \sum_{t=0}^{\infty} [\beta^t \phi u'(c_t)(c_t - w_t L + T_t)] - \phi A \end{aligned} \tag{19}$$

here, the parameters $\eta_{1t}, \eta_{2t}, \eta_{3t}$, ϕ are Lagrange multipliers for the constraints. We can get the dynamic equilibrium system for $\{c_t, K_{1t}, K_{2t}, L_{1t}, L_{2t}, \eta_{1t}, \eta_{2t}, \eta_{3t}, \phi\}$ using the first order conditions of variables c_t, $K_{1,\ t+1}, K_{2,t+1}, L_{1t}, L_{2t}$ of Equation (19) and constraints, which is Equations (14), (15) and (17). Specially, according to the analysis of the first order conditions at steady state we can get this conclusion below.

Proposition 1. *When $a > 1$, we have $s_2 > 0$; the greater the government's GDP incentives, the larger the subsidy s_2 to the automobile manufacturing sector, and the greater the gap of government's preferential support for automobile manufacturing sector and that for automobile maintenance sector.*

Proof. We only focus on the first order conditions of variables $K_{1,\ t+1}$, $K_{2,t+1}$ and c_t, at the steady state, which means we can omit the subscript of time, and they can be expressed as:

$$\eta_2 = a\beta[\eta_1 F_{1K} + (1-\delta)\eta_2], \tag{20}$$

$$\eta_2 = a\beta[\eta_2 F_{2K} + (1-\delta)\eta_2], \tag{21}$$

$$\eta_1 = u'(c) + \frac{\phi u''(c)(c - wL) + u'(c)}{a^t}. \tag{22}$$

From the steady state of Euler Equation, which is Equation (5), we can get:

$$\frac{1}{\beta} = 1 - \delta + \frac{r}{p}. \tag{23}$$

From the first order condition of the automobile maintenance sector, which is Equation (8), at the steady state, we can get:

$$F_{1K} = r/(1+s_1). \tag{24}$$

From the first order condition of the automobile manufacturing sector, which is Equation (9), at the steady state, we can get:

$$pF_{2K} = r/(1+s_2). \tag{25}$$

Substituting the conditions of Equations (8) and (23) into Equation (20), we can get:

$$\frac{1}{a\beta} - \frac{1}{\beta} + \frac{r}{p} = \frac{\eta_1 r}{\eta_2(1+s_1)}, \tag{26}$$

and substituting the conditions of Equations (9) and (23) into Equation (21), we can get:

$$\frac{1}{a\beta} - \frac{1}{\beta} + \frac{r}{p} = \frac{r}{p(1+s_2)}. \tag{27}$$

Then from Equation (27), since we assume as $a > 1$, the subsidy rate for the automobile manufacturing sector $s_2 > 0$, and s_2 increases with the increasing of a, which means the government indeed give subsidy to the automobile manufacturing firm, and the subsidy increases with the increasing of short term GDP incentive.

Then we will analyze the subsidy to the automobile maintenance firms. Dividing Equation (27) by Equation (26), we can get:

$$\frac{1+s_1}{1+s_2} = \frac{p\eta_1}{\eta_2}. \tag{28}$$

We can know that η_1 decreases with parameter a, while η_2 does not change with parameter a according to Equation (22) assuming $u''(c)$ is small enough, and the term $\phi u''(c)(c - wL) + u'(c)$ is positive. This means the shadow value of automobile maintenance service decrease when the government' GDP incentive is large. So $\frac{1+s_1}{1+s_2}$ will decrease with a, which means the gap of government's preferential support for automobile manufacturing sector and automobile maintenance sector increases with government's GDP incentive. □

These results can be interpreted as that the government pays more attention to future consumption and production, due to short-term GDP incentives and the limited tenure, which means the government utility is different with the consumer's because the consumer prefers the current consumption. Then the government subsidizes the firms in the automobile manufacturing sector that can be formed as capital and then more capital will produce more product and GDP because the capital is the necessity of the production process and has the multiplier effect in the process. Moreover, the larger the short-term GDP incentives, the larger the subsidies on the automobile manufacturing sector, and the larger gap between the subsidy given to the automobile manufacturing firm and the subsidy given to the automobile maintenance firm. That's why the government with short-term GDP incentive will intervene differently in the different sectors.

In the empirical part in Section 3, we will test the positive correlation of the government's short-term GDP incentives on the biased subsidy between the firms of automobile manufacture sector and firms of automobile maintenance sector. So we firstly propose the empirical hypothesis in Section 2.2 before the empirical research design.

2.2. Empirical Hypothesis

According to the theoretical analysis in Section 2.1, we know that when the government has short-term GDP incentives, he intervenes differently in automobile industries. In order to provide more capital for the entire economy to drive more output of all industries because of the multiplier effect of the capital in macroeconomics, the government will support the development of the automobile manufacturing sector with more subsidies, while the subsidies implemented in the automobile maintenance industry will be relatively less. The differential subsidies can reduce consumption and promote capital accumulation, thus, contribute to GDP growth. To prove the mechanism of our theoretical model and conclusion, we will give some empirical evidence about how the government's short term GDP incentive can affect the biased government intervention between the firms of automobile manufacture sector and firms of automobile maintenance sector. Furthermore, we will find the appropriate proxies of government intervention and government's short-term GDP incentives.

As for the measure of government intervention, the government subsidy is a kind of government intervention, and it is usually carried out in the form of preferential treatment or hidden subsidies for firms, which cannot be seen directly, however, the preferential treatment can be reflected in the degree of tax avoidance of firms. Although the tax collection is stipulated by the law of tax, the tax law also allows the government to implement tax reduction and tax preference accordingly, which induced that the actual tax rates of enterprises may not the actual tax rate ruled by the tax law. In addition, the government can use different taxation intensity; thus, the degrees of tax evasion of different enterprises are different. Thus, when the government has more GDP incentive, more preferential treatment will be given to automobile manufacturing enterprises, and the tax avoidance of these enterprises should be larger. So we use the tax avoidance of the firm to represent the degree of government intervention, and the larger tax avoidance, the large degree of government intervention. Since the government intervention is biased to automobile manufacturing enterprises and the biased gap increases with the government's GDP incentives, we have the following empirical hypothesis below.

Hypothesis 1. *The higher government's GDP incentives will increase the gap of tax avoidance between the automobile manufacturing enterprises and automobile maintenance enterprises.*

Table 1. Notation list.

Notifications	Definitions
u	Utility of the consumer.
$u(\cdot)$	Utility function.
c_t	Consumption of the consumer at time t.
K_t	Capital stock at time t.
K_{1t}	Capital used in automobile manufacturing production at time t.
K_{2t}	Capital used in automobile maintenance production at time t.
L	Fixed labor supply per period.
L_{1t}	Labor used in automobile manufacturing production at time t.
L_{2t}	Labor used in automobile maintenance production at time t.
β	Discount rate.
δ	Depreciation rate of capital.
p_t	Price of the automobile manufacturing production.
w_t	Wages of the labor.
r_t	Rent of capital.
T_t	Lump-sum tax on consumer's income.
λ_t	Lagrangian multiplier in consumer's problem of each period.
$F_1(\cdot)$	Production functions of automobile manufacturing firm.
$F_2(\cdot)$	Production functions of automobile maintenance firm.
π_1	Profit of automobile manufacturing firm.
π_2	Profit of automobile maintenance firm.
s_{1t}	Government subsidy ratios for automobile manufacturing firm.
s_{2t}	Government subsidy ratios for automobile maintenance firm.
a	Government's short-term GDP incentive intensity.
u_g	Utility of the government.
Γ	Lagrangian equation notation.
η_{1t}	Lagrange multipliers for automobile maintenance market constraint of each period.
η_{2t}	Lagrange multipliers for automobile manufacturing market constraint of each period.
η_{3t}	Lagrange multipliers for labor market constraint of each period.
ϕ	Lagrange multipliers for consumer's budget constraint.
A	Constant, and $A = u'(c_0)[r_0K_0 + p_0(1-\delta)K_0]$

3. Empirical Method

3.1. Setting up of Empirical Model

According to the theoretical model, it can be known that the greater the government's short-term GDP incentives, the greater the difference in preferential subsidies between the two kinds of firms. Since most of the preferential subsidies are invisible, we use indirect methods to measure the biased intervention policies of the government. Specifically, we use the difference between the actual income tax rates in the two kinds of firms to reflect the difference in government intervention bias. The gap of actual income tax rate and the statutory tax rate, induced by taxation intensity, can reflect the degree of government intervention. The lower the actual income tax rate, the greater the government's preferential subsidy. Since the pre-tax profit is usually not the real profit of the enterprise, the proportion of the income tax in pre-tax profit does not accurately reflect the actual income tax rate of the enterprise. Some researchers use tax avoidance to measure the actual tax rate of the firms [41,42], because the larger the tax evasion equals the lower actual tax rate, which also indicates the smaller government taxation intensity and the larger extent of the government intervention. We use the method of [41,42] to calculate the tax avoidance degree of the enterprise.

The idea of this method is like this. Although the reported profit is not the real profit of the enterprise, it is related to the real profit, and we can calculate the estimated profit, which is also not exactly the real profit, but related to it. Then there will be a large error if we use the difference between the estimated profit and the reported profit as the hidden profit of the enterprise. However, we can know that the estimated profit is related to the reported profit, and the greater the correlation, the smaller degree of the enterprise's tax avoidance. Thus, [41] measured the degree of tax avoidance of enterprises by calculating the sensitivity of estimated profit, which is based on the method of national income accounting, and the reported profit. Firstly, the estimated profit of the enterprise is highly correlated with the real profit π_{it}. It is assumed that the relationship between the real profit and the estimated profit is expressed as:

$$\pi_{it} = \eta_{it} + PRO_{it} + \theta_{it}, \tag{29}$$

here, the subscripts i and t represent the enterprise and the year, respectively. η_{it} is a constant, θ_{it} is a random error, and PRO is the estimated profit. According to the principle of national income accounting, the estimated profit can be expressed as:

$$PRO_{it} = \frac{Y_{it} - MED_{it} - FC_{it} - WAGE_{it} - DEP_{it} - VAT_{it}}{TAS_{it}}, \tag{30}$$

here, Y represents the total industrial output value of the enterprise; MED represents the total industrial input; FC represents the financial expenses; $WAGE$ represents the expenditure of wage expressed by the total payable wage; DEP is the depreciation this year; VAT is the amount of payable value added tax and TAS indicates the total assets of the enterprise.

Secondly, the industrial enterprise database discloses the pre-tax profit reported by the company, which is the reported profit of the enterprise, denoted by $RPRO$, and the reported profit of the enterprise is also related to the real profit π_{it}, which can be expressed as:

$$RPRO_{it} = d_{it}\pi_{it} + e_{it} + \xi_{it}, \tag{31}$$

here the reported profit $RPRO$ is defined as the ratio of total profit and total assets; e_{it} is the constant term; ξ_{it} is the random disturbance term; d_{it} is the sensitivity between the reported profit and the real profit, and the smaller value of d indicating the higher the degree of tax avoidance. According to the theoretical model, the government's GDP incentives will affect the difference between the actual tax burden of automobile manufacturing enterprises and automobile maintenance enterprises, which is the difference of sensitivity between the two kinds of firms. Therefore, we can express this impact as:

$$d_{it} = \beta_0 + \beta_1 VEHM_{it} + \beta_2 GOV_{it} + \beta_3 VEHM_{it} \times GOV_{it} + \chi X_{it} + \lambda_t + \gamma_j + \nu_{it}, \tag{32}$$

here, GOV indicates the government's incentive; $VEHM$ is a dummy variable which equals one if the firm belongs to the automobile manufacturing industry and zero otherwise; X indicates the firm level characteristic variables; λ_t represents the year fixed effect, and γ_j represents province fixed effect. β_1 presents the difference of sensitivity of reported profits to real profits between the manufacturing industry and the maintenance industry; β_2 indicates the influence of government incentives on the sensitivity of reported profits and real profits, and the coefficient β_3 of the interaction term $VEHM \times GOV$ indicates the difference of the impact of government's GDP incentives on sensitivity between automobile manufacturing firms and maintenance firms. Since the real profit of the enterprise cannot be observed, Equation (32) cannot be estimated directly. Therefore, we substitute the real profit represented by the estimated profit, which is Equation (29), into the expression of the reported profit, which is Equation (31) and then we can get

$$RPRO_{it} = d_{it}PRO_{it} + d_{it}\eta_{it} + e_{it} + \varepsilon_{it}, \tag{33}$$

here, $\varepsilon_{it} = \xi_{it} + d_{it}\theta_{it}$. Then we take the expression of the sensitivity d_{it} between the profit and the real profit, which is Equation (32), into the relationship between the estimated profit and the reported profit, which is Equation (33) and we finally get this expression:

$$\begin{aligned} RPRO_{it} = (&\beta_0 + \beta_1 VEHM_{it} + \beta_2 GOV_{it} + \beta_3 VEHM_{it} \times GOV_{it} + \beta_4 X_{it} + \lambda_t \\ &+\gamma_j\big) \times PRO_{it} + \alpha_0 + \alpha_1 VEHM_{it} + \alpha_2 GOV_{it} + \alpha_3 VEHM_{it} \times GOV_{it} \\ &+\alpha_4 X_{it} + \lambda_t + \gamma_j + \mu_{it}. \end{aligned} \tag{34}$$

Thus, the coefficient β_3 of the triple interaction term $VEHM \times GOV \times PRO$ indicates the difference of the impact of government's GDP incentives on sensitivity between automobile manufacturing firms and automobile maintenance firms. If β_3 is negative, it means that automobile manufacturing firms have been given more preferential support under government incentives, which lead to their larger tax avoidance compared with the automobile maintenance companies.

Referring to the relevant literature [41,42], we control other firm level variables, including the firm size (*SIZE*), which is expressed in terms of the natural logarithm of the company's total assets; the liability-asset ratio (*LEV*), which equals the ratio of total liabilities to total assets of an enterprise; the age of the firm (*AGE*), which is the logarithm of the difference between the establishment year and the sample year; the financial expense (*LOAN*), which is the ratio of interest expense to total assets; the proportion of exports (*EXPT*), which is the ratio of export delivery value to the total assets; the ratio of industrial sales to the total value of industrial output (*SALE*) and the dummy variable (*SOE*) that indicates whether the enterprise is a state-owned enterprise or not.

3.2. Variable Definition of Government Incentive

Literature on political promotion tournaments, fiscal decentralization, fiscal revenue incentives and GDP growth [34,36] all mentioned that fiscal decentralization leads to GDP and fiscal incentives of the local government. In addition, stronger fiscal autonomy is most directly related to GDP incentives compared with other policies that can be used by local governments. Since China introduced to reform and opening policies, economic growth has been the main task of the government. When the promotion of officials depends more on the performance of economic growth under the horizontal competition among regions, the GDP incentive of local governments through fiscal approach becomes stronger [34,35]. Therefore, fiscal decentralization is the best measure of GDP incentive of local governments. It can be considered that the fiscal decentralization is a measure of autonomy of local governments on fiscal revenue and expenditure, and the larger the degree of fiscal decentralization, the stronger the fiscal autonomy of local governments because of the higher financial autonomy and the higher resource utilization capacity.

The fiscal decentralization system reflects the division of fiscal power and administrative power between the central and local governments, especially the revenue and expenditure power delegated by the central government to local ones. So the fiscal decentralization index should reflect the degree of local governments' control over fiscal power and administrative power. Oates firstly adopted three indicators of fiscal revenue and expenditure to represent the degree of fiscal decentralization [58]. Zhang and Gong [35] defined a group of indicators that represent the ratio of local government's income, or expenditure to the central government ability to measure fiscal decentralization. Lv et al. [42] used the tax decentralization index to measure the tax sharing incentives of local government. Since fiscal revenue, especially tax revenue, can represent a large part of the government's financial power, thus, tax sharing incentive is consistent with fiscal decentralization. So we use the following three tax sharing indicators to define the government's GDP incentive referring to Lv et al. [42].

1. The sharing rate of value added tax, denoted as *VAT*—which is defined as the ratio of the *VAT* revenue in the fiscal revenue of the province to the *VAT* revenue collected by the tax department of the province.
2. The sharing rate of income tax, denoted as *INC*—which is defined as the ratio of income tax revenue in the fiscal revenue of the province to the income tax revenue collected by the tax department of the province.
3. The sharing rate total tax, denoted as *TAX*—which is defined as the ratio of the total tax revenue in the fiscal revenue of the province to the total tax revenue collected by the tax department of the province.

3.3. Data

The data in our research comes from two resources. Firstly, the firm level data of automobile manufacturing and maintenance enterprises come from the database of Chinese Industrial Enterprises from 1998 to 2007. Researches using this database usually only cover these years because the sample in this period is believed to be more valid and reasonable. After excluding samples with missing values and samples with negative values in some important enterprise characteristic variables (such as total assets, total liabilities, total profit and industrial sales value), we get a total of 44,268 observations. Secondly, the data of macroeconomic variables, which includes the total tax revenue, VAT revenue, the income tax revenue in the fiscal income of each province, the total tax revenue, VAT revenue, the income tax revenue collected by the tax authorities of each province that are all used to calculate the provincial government incentives, come from Wind database, Chinese Tax Yearbook and Chinese Fiscal Yearbook. Wind database is a large financial database in China.

4. Empirical Evidence

4.1. Descriptive Statistics

Table 2 presents the descriptive statistics of variables in our regression. We can see that 90% of firms in our sample are in the automobile manufacturing industry, which is consistent with the situation that the automobile industry is less developed in China. The mean of the sharing rate of value added tax, income tax and total tax are 23%, 63%, and 50%, respectively. The average logarithm of firm age is 2, and the mean of leverage is 1%, with the standard deviation of 2% and a maximum value of 10%. The average proportion of the exports is 11%, with the standard error of 38%. Moreover, 25% of firms are SOEs and 6% foreign firms in our sample; 97% of firms are in normal operation; and 3% of the firms belong to the central government and 3% belong to large firms.

Table 2. Descriptive statistics of each variable.

Variables	Observations	Mean	SD	Min	Median	Max
RPRO	44,268	0.09	0.14	0.00	0.05	0.95
PRO	44,268	0.23	0.46	−0.39	0.10	2.92
VEHM	44,268	0.90	0.30	0.00	1.00	1.00
VAT	44,268	0.23	0.03	0.19	0.23	0.27
INC	44,268	0.63	0.17	0.37	0.61	0.90
TAX	44,268	0.50	0.08	0.39	0.51	0.69
SIZE	44,268	9.87	1.65	0.69	9.67	18.17
AGE	44,268	2.00	0.99	0.00	1.95	7.60
LOAN	44,268	0.01	0.02	0.00	0.00	0.10
EXPT	44,268	0.11	0.38	0.00	0.00	2.40
SALE	44,268	0.97	0.08	0.67	0.99	1.27
SOE	44,268	0.25	0.44	0.00	0.00	1.00
FOREG	44,268	0.06	0.24	0.00	0.00	1.00
OPRT	44,268	0.97	0.18	0.00	1.00	1.00
CENTR	44,268	0.03	0.18	0.00	0.00	1.00
LARGE	44,268	0.03	0.18	0.00	0.00	1.00

4.2. The Impact of Government Incentive on Tax Avoidance

According to the theoretical model, when the government's GDP incentive is large, the government will increase preferential treatment for enterprises, which will lower the actual tax burden of enterprises, and the government's preferential policies favors more to automobile manufacturing enterprises, which contribute more to capital accumulation. Table 3 shows the regression results of the impact of government incentives on the actual tax burden and the differences of this impact between automobile manufacturing and maintenance enterprises. We did not list the coefficients of intersection terms between the annual dummy variables and the calculated profit *PRO* in the table, and the intersection between provincial dummy variables and the calculated profit *PRO* are also omitted for simplicity. All regressions used the robust standard error to avoid heteroscedasticity problems. No government incentive variable is added In Column (1) of Table 2. The coefficient of intersection term of *VEHM* and *PRO* represents the difference of actual tax burden between automobile manufacturing enterprises and maintenance enterprises, and the coefficient is not significant, which means the actual tax burden difference between the two enterprises is not significant if the influence of government incentives is not controlled. The regression results of Column (2–4) show the regression results controlling the government incentives. The coefficients of the $GOV \times PRO$ in the column (2–4) are insignificant or negative, which indicates that the greater the government's GDP incentive is, the larger preferential to the enterprises, and thus, the actual tax burden of enterprises will be reduced. However, we care more about the coefficients of the triple intersection terms of $VEHM \times GOV \times PRO$. In the Column (2–4), the coefficients of these terms of are all significantly negative, which shows that although the government's GDP incentive leads to the reduction of the actual tax burden of enterprises, however, what more important is that the government's intervention is biased, and the government gives more preferential subsidies to firms of automobile manufacturing industries. The government's GDP incentive plays a bigger role in reducing the actual tax burden of enterprises for automobile manufacturing enterprises than for automobile maintenance enterprises. For example, the coefficient of the triple interaction term in Column (4) is −0.4934, which indicates that the negative effect of government incentives on firm's tax burden is about 0.5 lower in the automobile manufacturing firms compared with the automobile maintenance firms. These results confirm the hypothesis and prove the conclusion of theoretical model empirically as well.

Table 3. The influence of government incentive on the sensitivity of reported profit and real profit.

	Dependent Variable: *RPRO*			
	(1)	**(2)**	**(3)**	**(4)**
	No *GOV*	***GOV* = *VAT***	***GOV* = *INC***	***GOV* = *TAX***
PRO_VEHM	−0.0166 (−1.61)	0.1723 *** (3.40)	0.0578 * (1.65)	0.2273 *** (4.09)
PRO_SIZE	0.0011 (0.63)	0.0006 (0.29)	0.0002 (0.13)	0.0019 (0.96)
PRO_AGE	0.0066 ** (2.11)	0.0072 ** (2.32)	0.0064 ** (2.05)	0.0064 ** (2.07)
PRO_LOAN	0.1077 (1.19)	0.1132 (1.25)	0.1043 (1.16)	0.1257 (1.39)
PRO_EXPT	−0.0156 ** (−2.44)	−0.0155 ** (−2.39)	−0.0153 ** (−2.40)	−0.0167 *** (−2.61)
PRO_SALE	0.1015 *** (5.11)	0.0947 *** (3.26)	0.0763 *** (2.79)	0.1561 *** (5.15)
PRO_SOE	0.0045 (0.61)	0.0036 (0.49)	0.0042 (0.57)	0.0050 (0.68)
PRO_FOREG	−0.0028 (−0.15)	−0.0023 (−0.12)	−0.0016 (−0.09)	0.0029 (0.16)

Table 3. *Cont.*

	Dependent Variable: *RPRO*			
	(1)	(2)	(3)	(4)
	No *GOV*	*GOV = VAT*	*GOV = INC*	*GOV = TAX*
PRO	−0.0004 *** (−3.91)	−0.0005 *** (−4.56)	−0.0005 *** (−4.15)	−0.0006 *** (−5.16)
VEHM	0.0111 *** (5.66)	0.0338 ** (2.23)	0.0015 (0.16)	−0.0056 (−0.51)
SIZE	−0.0038 *** (−9.52)	−0.0037 *** (−9.08)	−0.0036 *** (−8.97)	−0.0039 *** (−9.65)
AGE	−0.0090 *** (−14.65)	−0.0091 *** (−14.78)	−0.0089 *** (−14.60)	−0.0090 *** (−14.70)
LOAN	−0.0008 *** (−3.34)	−0.0006 *** (−2.78)	−0.0007 *** (−3.16)	−0.0007 *** (−2.84)
EXPT	0.0091 *** (4.45)	0.0091 *** (4.37)	0.0091 *** (4.49)	0.0094 *** (4.67)
SALE	0.0015 (1.29)	0.0015 (1.30)	0.0016 (1.31)	0.0013 (1.25)
SOE	−0.0091 *** (−5.98)	−0.0091 *** (−5.98)	−0.0090 *** (−5.89)	−0.0088 *** (−5.78)
FOREG	0.0169 *** (5.40)	0.0165 *** (5.25)	0.0167 *** (5.31)	0.0166 *** (5.30)
PRO_VEHM_GOV		−0.7748 *** (−3.73)	−0.0953 ** (−2.19)	−0.4750 *** (−4.31)
VEHM_GOV		−0.1003 (−1.59)	0.0126 (1.08)	0.0323 (1.53)
PRO_GOV		−0.0671 (−0.45)	0.0514 (1.40)	−0.2954 *** (−3.23)
GOV		0.1660 ** (2.34)	−0.0115 (−0.95)	−0.5370 *** (−6.04)
Constant	0.1450 *** (27.96)	0.1078 *** (6.53)	0.1507 *** (14.00)	0.3666 *** (9.97)
YEAR	YES	YES	YES	YES
*PRO * YEAR*	YES	YES	YES	YES
PROVINCE	YES	YES	YES	YES
*PRO * PROVINCE*	YES	YES	YES	YES
Observations	44,268	44,268	44,268	44,268
Adjusted R^2	0.35	0.35	0.35	0.35

Note: t statistics in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.3. The Influence of Government Incentive Changes on Tax Evasion of Different Types of Enterprises

4.3.1. Enterprises Ownership

The impact difference in government incentives varies in different types of enterprises. For example, it is generally believed that government interventions are different in enterprises with different ownership in the literature. On the one hand, state-owned enterprises will receive more preferential treatment and subsidies from the government. On the other hand, state-owned enterprises (SOEs) are mostly in the upstream industries, especially the manufacturing industry [59]. According to the theoretical model, enterprises in the automobile manufacturing industry, which is more likely to be the upstream industries, are more easily affected by the government incentives. So we conjecture that the difference of impact of government's GDP incentive tax avoidance between automobile manufacturing enterprise and automobile maintenance enterprise will be more significant in state-owned enterprises. Therefore, we divided the samples into SOEs and non-SOEs to compare this impact difference. We define the SOEs as the firms whose registration types are state-owned, collective or wholly state-owned firms. Table 4 showed the regression results of Equation (28) in SOEs and non-SOEs. We can see that the coefficients of triple interaction term $VEHM \times GOV \times PRO$ are all significantly negative in the group of SOEs, which is Column (1) (3) and (5), and the absolute value is larger than the coefficients in Table 3. However, the coefficients of triple interaction term $VEHM \times GOVPRO$ are not significant in the group of non-SOEs, i.e., Column (2) (4) and (6), which indicates that the bias of preferential government subsidies caused by GDP incentives is more obvious in SOEs. The government, which is inspired by GDP incentive, gives more subsidizes to upstream enterprises, especially state-owned enterprises. This behavior will induce a larger amount of investment in industries that are more helpful to capital accumulation, which will promote economic growth. These results further prove our conclusion in the theoretical model.

Table 4. Regression results of different ownership enterprises.

	Dependent Variable: *RPRO*					
	GOV = *VAT*		*GOV* = *INC*		*GOV* = *TAX*	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	SOE	**nSOE**	**SOE**	**nSOE**	**SOE**	**nSOE**
PRO_VEHM_GOV	−2.2074 *** (−6.28)	0.5450 ** (1.98)	−0.3651 *** (−5.73)	0.2024 *** (3.28)	−0.7655 *** (−4.78)	0.0538 (0.33)
VEHM_GOV	−0.0227 (−0.26)	−0.1985 ** (−2.09)	0.0580 *** (3.77)	−0.0606 *** (−3.61)	0.0050 (0.17)	0.0157 (0.45)
PRO_GOV	0.1401 (0.50)	−0.4679 ** (−2.55)	0.1278 ** (2.20)	−0.1619 *** (−3.08)	0.1082 (0.66)	−0.4560 *** (−4.13)
PRO_VEHM	0.5187 *** (5.98)	−0.1198 * (−1.86)	0.2628 *** (5.23)	−0.1511 *** (−3.05)	0.3582 *** (4.51)	−0.0102 (−0.12)
PRO_SIZE	−0.0016 (−0.42)	0.0022 (0.95)	−0.0022 (−0.61)	0.0025 (1.09)	−0.0010 (−0.26)	0.0033 (1.42)
PRO_AGE	−0.0017 (−0.30)	0.0085 ** (2.26)	−0.0011 (−0.20)	0.0088 ** (2.36)	−0.0024 (−0.42)	0.0089 ** (2.39)
PRO_LOAN	0.4067 ** (2.42)	−0.0237 (−0.22)	0.3307 ** (2.09)	−0.0175 (−0.16)	0.4190 ** (2.52)	−0.0094 (−0.09)
PRO_EXPT	−0.0308 (−1.58)	−0.0141 ** (−2.11)	−0.0129 (−0.60)	−0.0142 ** (−2.12)	−0.0254 (−1.29)	−0.0151 ** (−2.25)
PRO_SALE	0.0169 (0.32)	0.1773 *** (5.35)	0.0169 (0.34)	0.1842 *** (5.60)	0.0140 (0.25)	0.2226 *** (6.69)
PRO	−0.0008 *** (−5.07)	0.0002 (0.12)	−0.0007 *** (−4.69)	0.0003 (0.14)	−0.0009 *** (−5.49)	0.0005 (0.25)
VEHM	0.0159 (0.73)	0.0585 *** (2.59)	−0.0323 *** (−2.68)	0.0597 *** (4.55)	0.0092 (0.63)	0.0030 (0.16)
GOV	0.0413 (0.38)	0.1610 (1.57)	−0.0498 *** (−3.15)	0.0560 *** (3.11)	−0.3299 ** (−2.03)	−0.4196 *** (−3.87)
SIZE	−0.0065 *** (−9.45)	−0.0024 *** (−4.74)	−0.0064 *** (−9.60)	−0.0024 *** (−4.83)	−0.0066 *** (−9.62)	−0.0026 *** (−5.17)
AGE	−0.0113 *** (−11.01)	−0.0077 *** (−10.11)	−0.0113 *** (−11.02)	−0.0078 *** (−10.20)	−0.0112 *** (−10.93)	−0.0078 *** (−10.23)
LOAN	0.1052 ** (2.37)	−0.0009 (−0.73)	0.1197 *** (2.77)	−0.0009 (−0.76)	0.1277 *** (3.00)	−0.0010 (−0.82)
EXPT	0.0244 ** (2.30)	0.0082 *** (3.76)	0.0217 ** (2.05)	0.0082 *** (3.69)	0.0230 ** (2.11)	0.0084 *** (3.83)
SALE	−0.0000 (−0.10)	0.0043 * (1.74)	−0.0000 (−0.09)	0.0042 * (1.74)	−0.0000 (−0.05)	0.0039 * (1.79)

Table 4. *Cont.*

	Dependent Variable: *RPRO*					
	GOV = *VAT*		*GOV* = *INC*		*GOV* = *TAX*	
	(1)	(2)	(3)	(4)	(5)	(6)
	SOE	nSOE	SOE	nSOE	SOE	nSOE
PRO_FOREG		−0.0054 (−0.29)		−0.0070 (−0.37)		−0.0044 (−0.23)
FOREG		0.0163 *** (5.16)		0.0168 *** (5.28)		0.0164 *** (5.18)
Constant	0.1691 *** (6.88)	0.0791 *** (3.29)	0.2144 *** (14.37)	0.0752 *** (5.06)	0.3103 *** (4.63)	0.2938 *** (6.46)
YEAR	YES	YES	YES	YES	YES	YES
*PRO * YEAR*	YES	YES	YES	YES	YES	YES
PROVINCE	YES	YES	YES	YES	YES	YES
*PRO * PROVINCE*	YES	YES	YES	YES	YES	YES
Observations	11,286	32,982	11,286	32,982	11,286	32,982
Adjusted R^2	0.45	0.32	0.44	0.32	0.44	0.32

Note: t statistics in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.3.2. Firm Size

Large enterprises playing a greater role in capital accumulation, and the government tend to "seize the large enterprises and release the small ones" [60], so large enterprises are more like to be the government's target and can promote GDP growth better. Therefore, if the government conducts a differential intervention on enterprises in different industries, due to the GDP incentive, we conjecture that the effect of a government tax incentive on reducing the actual tax burden of manufacturing enterprises will be more obvious in large enterprises. Therefore, we group the samples by firm size disclosed in the industrial enterprise database. The large firms include the enterprises with the label of "large scale", "super scale", "large type 1" and "large type 2", and the small firms include the enterprises with the label of "medium", "medium type 1", "medium type 2" and "small". Table 5 shows the regression results of the Equation (28) in firms with different size. We can see that all the coefficients of triple interaction terms are significantly negative, and the values are large in large firms' group. These results show that the phenomenon of the difference of intervention caused by government incentive is more apparent in large size enterprise, and the biased subsidies and preferential policies are given by the government to the automobile manufacturing industry are more likely to occur in large enterprises. These results prove our hypothesis, as well.

Table 5. Regression results of enterprises of different sizes.

	Dependent Variable: *RPRO*					
	GOV = *VAT*		*GOV* = *INC*		*GOV* = *TAX*	
	(1)	(2)	(3)	(4)	(5)	(6)
	LARGE	SMALL	LARGE	SMALL	LARGE	SMALL
PRO_VEHM_GOV	−1.3817 *** (−10.22)	−1.1970 *** (−4.54)	−0.1259 *** (−4.21)	−0.0886 *** (−3.17)	−0.4356 *** (−4.44)	−0.3980 *** (−7.65)
VEHM_GOV	0.0956 * (1.66)	−0.1238 (−1.58)	0.0081 (0.88)	0.0160 ** (2.20)	0.0732 *** (3.28)	0.0270 *** (2.59)
PRO_GOV	0.3859 *** (3.56)	0.2338 (1.21)	0.2129 *** (7.67)	0.0745 *** (2.95)	0.0594 (0.69)	0.1101 ** (2.50)
PRO_VEHM	0.3358 *** (10.12)	0.2780 *** (4.37)	0.0839 *** (3.61)	0.0531 ** (2.43)	0.2188 *** (4.25)	0.2030 *** (7.84)

Table 5. *Cont.*

	Dependent Variable: *RPRO*					
	GOV = VAT		*GOV = INC*		*GOV = TAX*	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	LARGE	**SMALL**	**LARGE**	**SMALL**	**LARGE**	**SMALL**
PRO_SIZE	−0.0139 *** (−11.65)	−0.0055 * (−1.75)	−0.0130 *** (−11.08)	−0.0036 ** (−2.21)	−0.0126 *** (−8.36)	−0.0076 *** (−7.17)
PRO_AGE	−0.0008 (−0.48)	0.0068 (1.63)	−0.0005 (−0.27)	0.0062 *** (3.00)	0.0007 (0.34)	0.0016 (1.20)
PRO_LOAN	−0.1972 *** (−4.42)	0.0786 (0.57)	−0.1941 *** (−4.28)	0.0961 (1.17)	−0.1060 * (−1.88)	0.1929 *** (3.45)
PRO_EXPT	−0.0434 *** (−11.67)	0.0074 (0.63)	−0.0440 *** (−12.05)	0.0001 (0.02)	−0.0441 *** (−9.74)	0.0032 (0.77)
PRO_SALE	0.2440 *** (12.56)	0.0438 (1.23)	0.2221 *** (11.31)	0.0522 *** (3.14)	0.2634 *** (10.17)	0.0746 *** (5.71)
PRO_SOE	−0.0218 *** (−5.24)	0.0140 (1.49)	−0.0267 *** (−6.51)	0.0154 *** (3.13)	−0.0222 *** (−4.38)	0.0061 * (1.82)
PRO_FOREG	0.0620 *** (6.01)	−0.0039 (−0.14)	0.0538 *** (5.17)	0.0172 (1.22)	0.0418 *** (2.92)	0.0246 *** (2.76)
PRO	−0.0043 (−1.43)	−0.0007 *** (−5.23)	−0.0022 (−0.71)	−0.0012 * (−1.76)	−0.0004 (−0.15)	−0.0017 *** (−5.04)
VEHM	−0.0204 (−1.47)	0.0381 ** (2.00)	−0.0036 (−0.49)	−0.0058 (−1.03)	−0.0333 *** (−2.88)	−0.0112 ** (−2.10)
GOV	−0.0523 (−0.84)	0.2415 *** (2.68)	−0.0217 ** (−2.30)	−0.0254 *** (−3.21)	−0.4713 *** (−6.59)	−0.0537 (−1.16)
SIZE	−0.0041 *** (−15.01)	−0.0118 *** (−15.75)	−0.0042 *** (−15.29)	−0.0076 *** (−19.22)	−0.0039 *** (−11.98)	−0.0065 *** (−25.58)
AGE	−0.0080 *** (−19.26)	−0.0079 *** (−9.42)	−0.0080 *** (−19.25)	−0.0062 *** (−12.19)	−0.0078 *** (−15.94)	−0.0042 *** (−12.46)
LOAN	0.0009 (0.45)	0.1756 *** (3.80)	−0.0005 (−0.23)	0.1404 *** (4.47)	−0.0016 (−0.98)	0.1659 *** (9.09)
EXPT	0.0195 *** (13.61)	0.0060 ** (2.36)	0.0194 *** (13.60)	0.0064 *** (4.96)	0.0169 *** (7.77)	0.0074 *** (8.42)
SALE	0.0073 *** (3.06)	0.0004 (0.54)	0.0075 *** (3.01)	0.0002 (0.40)	0.0089 *** (2.87)	0.0025 * (1.82)
SOE	−0.0089 *** (−8.87)	−0.0036 * (−1.65)	−0.0088 *** (−8.75)	−0.0053 *** (−4.03)	−0.0100 *** (−8.40)	−0.0029 *** (−3.36)
FOREG	0.0185 *** (9.32)	0.0214 *** (4.55)	0.0195 *** (9.77)	0.0137 *** (5.29)	0.0238 *** (9.44)	0.0127 *** (7.40)
Constant	0.1509 *** (10.04)	0.1355 *** (6.35)	0.1543 *** (18.46)	0.1557 *** (20.84)	0.3339 *** (11.27)	0.1345 *** (7.11)
YEAR	YES	YES	YES	YES	YES	YES
*PRO*YEAR*	YES	YES	YES	YES	YES	YES
PROVINCE	YES	YES	YES	YES	YES	YES
*PRO*PROVINCE*	YES	YES	YES	YES	YES	YES
Observations	18,283	22,135	18,271	21,413	20,269	19,038
Adjusted R^2	0.66	0.34	0.66	0.44	0.56	0.56

Note: t statistics in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

4.3.3. Firm Belongs

The short-term GDP incentive of the government mainly refers to the incentive of local governments. The government tends to implement policies more effectively for enterprises that are close to it considering asymmetric information; thus, the enterprises far away are more likely to be decentralized to lower level of local governments [61]. Therefore, the local governments tend to give more intervention to enterprises that are in their jurisdiction for GDP growth. So we grouped the samples into local and non-local enterprises groups according to the level of enterprise registration authorities disclosed in the industrial enterprise database. Local enterprise refers to the firms whose enterprise registration authority is not a state. Table 6 shows the regression results in the different groups. We can see that the coefficient of triple interaction terms is all significantly negative in the local group, which are the Column (2) (4) and (6). However, they are insignificant in the group of central government authorized firms, which are the Column (1) (3) and (5). The results also suggest that the phenomenon of differential intervention caused by government incentives is more obvious in local firms. This may because the biased subsidies and preferential policies that the government gives to the automobile industry are more likely to occur in the local firm under jurisdiction.

Table 6. Regression results of central and local enterprises.

	Dependent Variable: *RPRO*					
	GOV* = *VAT		***GOV* = *INC***		***GOV* = *TAX***	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	CENTR	**LOCAL**	**CENTR**	**LOCAL**	**CENTR**	**LOCAL**
PRO_VEHM_GOV	−0.2966 (−0.48)	−0.7750 *** (−3.67)	0.0913 (0.50)	−0.0811 *** (−2.70)	−0.0114 (−0.02)	−0.4638 *** (−4.06)
VEHM_GOV	0.0353 (0.37)	−0.0920 (−1.37)	0.0066 (0.28)	0.0006 (0.08)	0.0325 (0.53)	0.0371 (1.60)
PRO_GOV	0.1970 (0.42)	−0.0716 (−0.47)	0.1946 (1.19)	0.0566 ** (2.25)	0.5439 (1.24)	−0.2408 *** (−2.60)
PRO_VEHM	0.0500 (0.35)	0.1627 *** (3.15)	−0.1222 (−0.93)	0.0339 (1.42)	−0.0438 (−0.20)	0.2126 *** (3.68)
PRO_SIZE	0.0141 *** (4.15)	0.0004 (0.17)	0.0191 ** (2.24)	0.0015 (1.18)	0.0177 ** (1.99)	0.0013 (0.64)
PRO_AGE	0.0146 * (1.86)	0.0070 ** (2.21)	−0.0038 (−0.25)	0.0099 *** (5.17)	−0.0043 (−0.27)	0.0063 ** (1.98)
PRO_LOAN	−1.7017 ** (−2.16)	0.0874 (0.97)	−1.8410 (−0.82)	0.1293 * (1.89)	−1.8837 (−0.88)	0.1005 (1.11)
PRO_EXPT	−0.0951 (−1.39)	−0.0161 ** (−2.50)	−0.0588 (−0.59)	−0.0184 *** (−4.16)	−0.0492 (−0.48)	−0.0171 *** (−2.69)
PRO_SALE	−0.0410 (−0.41)	0.1053 *** (3.56)	−0.1465 (−1.12)	0.0577 *** (3.26)	−0.1975 (−1.22)	0.1510 *** (4.92)
PRO_SOE	−0.1054 *** (−3.98)	0.0069 (0.93)	−0.1440 *** (−3.37)	−0.0001 (−0.03)	−0.1482 *** (−3.38)	0.0073 (0.99)
PRO	−0.0318 *** (−3.05)	−0.0005 *** (−4.72)	−0.0204 (−0.93)	−0.0003 *** (−6.30)	−0.0208 (−0.92)	−0.0006 *** (−5.35)
VEHM	−0.0029 (−0.12)	0.0327 ** (2.02)	0.0015 (0.08)	0.0086 (1.42)	−0.0102 (−0.35)	−0.0071 (−0.59)
GOV	−0.1764 (−1.28)	0.1571 ** (2.09)	−0.0345 (−1.31)	−0.0037 (−0.46)	0.1539 (0.77)	−0.5295 *** (−5.80)
SIZE	−0.0011 * (−1.68)	−0.0039 *** (−8.86)	−0.0025 * (−1.72)	−0.0010 *** (−3.34)	−0.0024 (−1.56)	−0.0041 *** (−9.24)
AGE	−0.0041 *** (−3.22)	−0.0091 *** (−14.43)	−0.0061 *** (−2.71)	−0.0085 *** (−18.85)	−0.0063 *** (−2.79)	−0.0091 *** (−14.39)

Table 6. *Cont.*

	Dependent Variable: *RPRO*					
	GOV = *VAT*		*GOV* = *INC*		*GOV* = *TAX*	
	(1)	(2)	(3)	(4)	(5)	(6)
	CENTR	LOCAL	CENTR	LOCAL	CENTR	LOCAL
LOAN	−0.0668 (−0.90)	−0.0006 *** (−2.61)	0.1081 (0.43)	0.0565 *** (2.63)	0.0977 (0.40)	−0.0006 *** (−2.72)
EXPT	−0.0152 (−0.79)	0.0093 *** (4.49)	−0.0381 (−1.57)	0.0091 *** (5.89)	−0.0390 (−1.60)	0.0096 *** (4.76)
SALE	0.0009 (0.42)	0.0015 (1.27)	0.0039 (0.76)	0.0016 (1.35)	0.0040 (0.74)	0.0013 (1.24)
SOE	−0.0220 *** (−6.03)	−0.0087 *** (−5.51)	−0.0158 *** (−2.94)	−0.0084 *** (−7.41)	−0.0156 *** (−2.83)	−0.0084 *** (−5.28)
PRO_FOREG		−0.0012 (−0.07)		0.0228 ** (2.13)		0.0036 (0.19)
FOREG		0.0168 *** (5.29)		0.0147 *** (6.77)		0.0168 *** (5.34)
Constant	0.1089 *** (3.70)	0.1130 *** (6.40)	0.1179 *** (4.95)	0.1107 *** (15.34)	0.0299 (0.37)	0.3658 *** (9.68)
YEAR	YES	YES	YES	YES	YES	YES
*PRO*YEAR*	YES	YES	YES	YES	YES	YES
PROVINCE	YES	YES	YES	YES	YES	YES
*PRO*PROVINCE*	YES	YES	YES	YES	YES	YES
Observations	1488	42,744	1524	41,775	1524	42,744
Adjusted R^2	0.30	0.35	0.21	0.43	0.21	0.35

Note: t statistics in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5. Robustness Check

We do robustness check to make sure that our results are invalid. We used only the sample firms whose business status is normal operation. The business status of enterprises can be divided into business, closure, preparation, the closed, the bankruptcy, and other six states, according to the database of China's industrial enterprises. The enterprise in the state of abnormal operating may have biased tax avoidance, and the only enterprise in the state of normal operating can reflect the actual level of government intervention. Therefore, we only keep the firms who are in normal business status. There are 1492 companies are dropped, and Table 7 shows the regression results. We can see that the regression results are similar to the results in Table 3. For example, the first coefficient of triple interaction term $PRO \times VEHM \times VAT$ in Column (2) is −0.8267, which is significant. These results show that the intervention on automobile manufacturing firms is biased as well, which is consistent with our previous results.

Table 7. Robust Check: Only firms in operation.

	(1)	(2)	(3)	(4)
	RPRO	*RPRO*	*RPRO*	*RPRO*
PRO_VEHM	−0.0163 (−1.57)	0.1854 *** (3.57)	0.0537 (1.53)	0.1997 *** (3.43)
PRO_SIZE	−0.0003 (−0.18)	−0.0011 (−0.52)	−0.0013 (−0.67)	0.0003 (0.16)
PRO_AGE	0.0059 * (1.84)	0.0066 ** (2.07)	0.0057 * (1.78)	0.0057 * (1.77)

Table 7. *Cont.*

	(1)	(2)	(3)	(4)
	RPRO	*RPRO*	*RPRO*	*RPRO*
PRO_LOAN	−0.0698 (−0.70)	−0.0577 (−0.58)	−0.0720 (−0.72)	−0.0590 (−0.58)
PRO_EXPT	−0.0250 *** (−3.91)	−0.0249 *** (−3.85)	−0.0246 *** (−3.84)	−0.0242 *** (−3.76)
PRO_SALE	0.1188 *** (5.86)	0.1108 *** (3.80)	0.0921 *** (3.40)	0.1582 *** (5.24)
PRO_SOE	0.0066 (0.88)	0.0052 (0.70)	0.0060 (0.81)	0.0071 (0.96)
PRO_FOREG	0.0024 (0.13)	0.0031 (0.17)	0.0035 (0.19)	0.0050 (0.27)
PRO	−0.0003 (−0.26)	−0.0005 (−0.38)	−0.0006 (−0.43)	0.0001 (0.07)
VEHM	0.0103 *** (5.16)	0.0353 ** (2.30)	0.0004 (0.05)	−0.0019 (−0.18)
SIZE	−0.0034 *** (−8.39)	−0.0033 *** (−7.93)	−0.0032 *** (−7.81)	−0.0035 *** (−8.51)
AGE	−0.0090 *** (−14.57)	−0.0091 *** (−14.69)	−0.0090 *** (−14.55)	−0.0090 *** (−14.58)
LOAN	0.1037 *** (3.49)	0.0989 *** (3.30)	0.1028 *** (3.47)	0.1034 *** (3.49)
EXPT	0.0113 *** (5.63)	0.0114 *** (5.53)	0.0113 *** (5.65)	0.0112 *** (5.55)
SALE	0.0013 (1.25)	0.0014 (1.26)	0.0015 (1.28)	0.0012 (1.21)
SOE	−0.0071 *** (−4.63)	−0.0070 *** (−4.59)	−0.0070 *** (−4.54)	−0.0072 *** (−4.69)
FOREG	0.0162 *** (5.19)	0.0157 *** (5.01)	0.0159 *** (5.08)	0.0159 *** (5.10)
PRO_VEHM_GOV		−0.8267 *** (−3.90)	−0.0897 ** (−2.05)	−0.4221 *** (−3.67)
VEHM_GOV		−0.1098 * (−1.73)	0.0128 (1.11)	0.0237 (1.13)
PRO_GOV		−0.0618 (−0.41)	0.0543 (1.48)	−0.2367 ** (−2.51)
GOV		0.1651 ** (2.31)	−0.0054 (−0.45)	−0.1055 (−1.16)
Constant	0.1398 *** (27.33)	0.1024 *** (6.15)	0.1408 *** (13.43)	0.1873 *** (5.03)
YEAR	YES	YES	YES	YES
*PRO*YEAR*	YES	YES	YES	YES
PROVINCE	YES	YES	YES	YES
*PRO*PROVINCE*	YES	YES	YES	YES
Observations	42,776	42,776	42,776	42,776
Adjusted R^2	0.35	0.35	0.35	0.35

Note: t statistics in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

6. Conclusions

The automobile manufacturing industry developed rapidly in China; however, the automobile maintenance industry less developed. In addition to the factors from the demand and supply side in the market, we tried to explain this fact from the perspective of government incentive and intervention in China. Firstly, we established a two-sector model with government incentives and government intervention, and then we analyzed the game between the government and market, and the optimal subsidy policy under the government's GDP incentive is obtained. The results of the theoretical model show that the government gives more preferential policies to automobile manufacturing firms compare to firms in automobile maintenance industries under short term GDP incentive. That's why the development of the automobile manufacturing and maintenance industry is unbalanced. Secondly, we use three indicators to represent the government GDP incentive under fiscal decentralization and test the differential impact of GDP incentive on tax avoidance of the two kinds of firms empirically. The empirical results show that the GDP incentive of the government caused by fiscal decentralization induced more preferential treatment to automobile manufacturing enterprises, and thus, increase their tax evasion degree, which proves the mechanism of government incentive in our theoretical model.

Understanding the incentive and implementation of industrial policy can help us understand the evolution mechanism of China's automobile industrial policy and automobile industrial structure better. Well-developed automobile maintenance industrial can improve customer loyalty that can help the automobile manufacture company survive in this highly competitive industry; with the increase of new kinds of vehicles and customer's requirements, it is necessary for the automotive service industry to constantly improve its development mode and introduce new technologies; and the balanced growth of automobile manufacturing and maintenance industry is one of the driving forces for market sustainability of automobile industry and sustainable regional growth. Based on these facts, we propose that, in an initial phase of the development of the automotive industry, the automobile manufacturing industry, which is upstream industry, should be encouraged to develop more than automobile maintenance industry, which is downstream industry, because the latter would have no reason to exist if the upstream industries did not exist. However, China may pay more attention to rebalancing the weight of the two industries after passing this first phase as economic develops. In this new phase, some measures,, such as reducing the short term GDP incentive of local government and making the performance evaluation more diversified, will lead to better policy that promotes the transformation and upgrading of the whole automobile industrial structure, even the whole industrial structure optimization and economic growth.

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Appendix A

Proof of the result of Equation (18).

Proof. The consumer's budget constraint when $t = 0$ is:

$$c_0 - w_0 L + T_0 = p_0\left[\frac{r_0}{p_0}K_0 + (1-\delta)K_0 - K_1\right]. \tag{A1}$$

The consumer's budget constraint when $t = 1$ is:

$$c_1 - w_1 L + T_1 = p_1\left[\frac{r_1}{p_1}K_1 + (1-\delta)K_1 - K_2\right]. \tag{A2}$$

The consumer's budget constraint when t = 2 is:

$$c_2 - w_2 L + T_2 = p_2 \left[\frac{r_2}{p_2} K_2 + (1-\delta) K_2 - K_3 \right]. \tag{A3}$$

From the Equation (5), we can get

$$\frac{\beta u'(c_{t+1})}{u'(c_t)} = \frac{p_t}{p_{t+1}} \frac{1}{r_{t+1}/p_{t+1} + (1-\delta)}. \tag{A4}$$

Therefore, we can know that $\frac{\beta u'(c_1)}{u'(c_0)} = \frac{p_0}{p_1} \frac{1}{r_1/p_1 + (1-\delta)}$. Multiply the left hand of Equation (A2) by $\frac{\beta u'(c_1)}{u'(c_0)}$ and multiply the right hand of Equation (A2) by $\frac{p_0}{p_1} \frac{1}{r_1/p_1 + (1-\delta)}$, and then we can get:

$$\frac{\beta u'(c_1)}{u'(c_0)} (c_1 - w_1 L + T_1) = p_0 \left[K_1 - \frac{K_2}{\frac{r_1}{p_1} + (1-\delta)} \right]. \tag{A5}$$

Multiply the left hand of Equation (A3) by $\frac{\beta^2 u'(c_2)}{u'(c_0)}$ and multiply the right hand of Equation (A3) by $\frac{p_1}{p_2} \frac{1}{r_2/p_2 + (1-\delta)} \times \frac{p_0}{p_1} \frac{1}{r_1/p_1 + (1-\delta)}$, and then we can get:

$$\frac{\beta^2 u'(c_2)}{u'(c_0)} (c_2 - w_2 L + T_2) = p_0 \left[\frac{K_2}{r_1/p_1 + (1-\delta)} - \frac{K_3}{[r_2/p_2 + (1-\delta)][r_1/p_1 + (1-\delta)]} \right], \tag{A6}$$

and so on. We add up all the results from Equation (A1), i.e., (A1) + (A5) + (A6) + ... , and we can get

$$\sum_{t=0}^{\infty} \beta^t \frac{u'(c_t)}{u'(c_0)} (c_t - w_t L + T_t) = [r_0 K_0 + p_0 (1-\delta) K_0]. \tag{A7}$$

This is the same with Equation (18) in Section 2. □

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Sustainable Development for Small Economy and Diversification from a Dominant Industry: Evidence from Macao

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Abstract: While the Macao gambling industry has developed prosperously, its rapid development raises a problem of economic dependence on gambling that restricts economic diversification and causes a sustainable issue of non-gambling industries. In recent years, regulating and controlling the appropriate scale of the gambling industry have been regarded as a solution for sustainable economic development. Consequently, it is quite important to give a quantitative scale to the future development of the gambling industry. This study aims to estimate the appropriate scale of the gambling industry under the expectation of the optimal development of moderate economic diversification in Macao. This study employs the method of Measuring Economic Diversification in Hawaii in 2011 to evaluate the levels of diversification of Macao's economy. A Data Envelopment Analysis (DEA) efficiency calculated by a bootstrapping model is applied to obtain the operational efficiency of Macao's gambling industry. A transition probability matrix in three scenarios is predicted by expert interviews and industry interviews. The appropriate scale of Macao's gambling industry until 2021 is forecasted by Markov chain. The predicted result shows that the growth rate of gambling will not exceed 3% in terms of achieving the goal of optimal developing moderate economic diversification in Macao.

Keywords: sustainability; gambling industry; economic diversification; dominant industry; Macao

1. Introduction

As a leading gambling destination, in 2017, Macao attracted more than 30 million tourists and created the highest gambling revenue (33 billion US dollars) in the world [1]. The development of Macao's gambling industry is the result of its history, economic development, resource limitations and preferential policy [2]. Although these factors helped Macao to obtain a competitive advantage in gambling tourism, this typical small economy raises a problem—economic dependence on gambling restricts economic diversification. The gambling industry increases labor wages and provides good treatment, which results in its strong absorption of economic resources. However, faster growth of gambling industry leads to higher income inequality [3] which limits other industries' survival and development. Scholars contend that a low level of diversification or concentrated economy can dramatically react to external influences, such as changes in demand for one product [4,5] and a diversified regional economy is less responsive to fluctuations to extra-regional economic growth [6].

Since diversification can reduce a nation's economic volatility and increase its real activity performance, so having a diverse economy has long been thought to play a key role in a sustainable economy [5]. Therefore, both the Macao government [7–10] and scholars [11–14] have recognized the importance of economic diversification, which is the source of long-term economic growth [5,15,16]. Moderate diversification of the economic structure is a way to drive economic sustainability in Macao. Thus, it is critical to establish moderate economic diversification in Macao.

To establish a moderate economic structure, the Macao government is facilitating the development of other industries, such as Meetings, Incentives, Conferences and Exhibitions (MICE), Traditional Chinese Medicines (TCM), Cultural and Creative Industries (CCI) and featured financial services. The Macao government also announced its policy spindle for gambling industry development, "adjustment of the appropriate scale of gambling industry" [7,9]. Recently, some researchers have studied the sources of threats and challenges to Macao's economic development [11,17], the ways Macao's economy is developing and diversifying [11,13,14,17,18] and sustainable tourism development in Macao [12]. They supported the development of moderate economic diversification and agreed that by controlling the scale of the gambling industry, more resources could be unlocked and reallocated to non-gambling industries [19]. However, some academics advocate the advantages of cluster economies or agglomeration economies [20–22], which have the advantages of sharing common resources (i.e., technology and labor), lower unit costs and better innovations for increasing returns to scale and enhancing the growth opportunities of other industries and clusters [20–22]. In a recent study, Aratuo and Etienne [23] studied the relationship between economic growth and tourism-related industries in the US in 1998–2017. They found that tourism-related industries providing local offerings drive the performance of other industries. Although most of the research on agglomeration economies and cluster economies consider the agglomeration of manufacturing industries [24,25], the agglomeration of service industries may occur if they can benefit from the concentration of customers [25]. Therefore, Macao's gambling industry tends to concentrate in certain areas in Macao instead of being scattered across Macao. Considering the needs for supporting service industries such as banks and other financial intermediaries, restaurants, tourism and other business services, the agglomeration of casinos can derive similar benefits to the agglomeration of manufacturing industries, especially regarding the enhancement of the growth opportunities of other industries and clusters [22]. In other words, the agglomeration of casinos may lead to the growth of other industries and clusters. This implies that over-adjustment of the gambling industry may harm the development of moderate economic diversification in Macao. Thus, how to strike a balance between moderate economic diversification and further development of the gambling industry must be determined.

The concept of appropriate scale comes from the economies of scale. Appropriate extension or reduction of the production scale will make the distribution of production factors, like land, capital and labor, more reasonable and will achieve optimal management efficiency under existing conditions [26,27]. To adjust the scale of the gambling industry appropriately, we should know how to calculate this 'appropriate scale.' In general, if the scale of the gambling industry is higher than this 'appropriate scale,' it will limit the development of moderate economic diversification. Then, it causes the sustainable issue of non-gambling industries. On the other hand, if the scale of the gambling industry is lower than this 'appropriate scale,' it will also reduce its support of non-gambling industries to achieve a moderate and diversified economy. It causes the sustainable issue for both gambling and non-gambling industries. Therefore, our study relates the appropriate scale of the gambling industry not only in terms of the economic efficiency of this industry but also the overall economic diversification in Macao. This study helps to address the paradox between economic growth of the gambling industry and sustainable growth of non-gambling industries.

To contribute to a solution for sustainable economic development in Macao, this study aims to determine the appropriate scale of the gambling industry for optimal development of moderate economic diversification in Macao. Firstly, this study applies an entropy index of economic diversification [28] to measure the levels of diversification of Macao's economy from 2008–2016.

Then, a Data Envelopment Analysis (DEA) [29–31] is used to measure the efficiency of the gambling industry. A transition probability matrix for three scenarios (rapid, stable and slow transitions) is developed based on expert interviews. To evaluate the appropriate scale, a Markov chain [32] is applied to forecast the future scale of the non-gambling industry and the gambling industry until 2021. The results of this study can be applied to other gambling destinations (such as Cambodia) that may soon face a similar sustainable economic problem of a concentration in the gambling industry and may want to promote industrial diversification. For sustainable economic growth caused by technological innovation and human capital accumulation, it is essential to transform and upgrade the industrial structure. This study also contributes to sustainability through the understanding of the transformation of the industrial structure and its relationship with sustainable economic growth.

2. Literature Review

2.1. Economic Diversification

The economy with a dominant industry is destined to create unsustainable economic development. The decline of Detroit's economy because of its over-reliance on the automotive industry is an example. Therefore, scholars have proposed the need for economic diversification, a strategy to transform an economy from relying on a single source to having multiple sources of monetary income spread over primary, secondary and tertiary industries [16]. Conceptually, Nourse [6] and Hackbert and Anderson [4] stated that economic diversification can build resilience against fluctuations in extra-regional economic activity and reduce dramatic reactions to external influence, such as changes in demand for one product. Empirically, measures of economic diversification include entropy measures [4,33], portfolio variance measure [34] and the Ogive index [35]. As a test of such measures, higher industrial diversification, as measured by entropy measures and the portfolio variance measure, was shown to lead to lower economic instability using samples of US [33,34].

International bodies, for example, the International Monetary Fund and United Nations, have committed to promoting economic diversification for sustainable economic development in resource-rich countries (i.e., countries within the Gulf Cooperation Council) [15,36] and Asian Landlocked Developing Countries [37] to reduce their economic volatility. However, since Macao is neither a resource-rich region nor a landlocked region, its case for moderate economic diversification will be a good example.

2.2. Moderate Economic Diversification and Sustainable Development in Macao

Macao's economic development has been dominated by the gambling industry. First, is manifested in its proportion of GDP. After the end of the monopoly system of the gambling industry in 2002, the proportion of GDP attributable to the gaming industry increased from 40.9% in 2006 to 63% in 2011. Although the proportion of GDP decreased from 63% in 2011 to 47.2% in 2016, the gambling industry still dominated a large percentage of Macao's economy [8]. The dominant industry raises a threat to Macao's economy [11]. Second, since labor is a key determinant of tourism efficiency and productivity [38], the gambling industry of Macao employs the largest percentage of the working population. From 2007 to 2016, the gambling industry employed about 23% to 26% of the working population [8]. Such a domination in gambling makes Macao vulnerable to a decline in the demand for gambling, which may arise from competing destinations such as Phnom Penh in Cambodia, Singapore and Japan, community alienation, slower growth of China's economy and Chinese government policies [11]. The decline in gambling demand in 2015 and 2016 following a crackdown by the Chinese government on corruption involving junket operators contributed to a corresponding plunge in Macao's GDP [8]. This situation makes economic diversification and sustainable development of Macao a vital issue.

Apart from economic volatility, negative externalities, for example, inflation, the rise of rental and property prices, increases in the cost of living, traffic problems, an increase in criminal cases and gambling-related crimes were identified by Macao's citizens [39–41]. Because of the high volume of tourists, as measured by the Tourism Intensity Index and negative externalities, there may be increasing negative aspects of resident–tourist relations that detrimentally affect the gambling and tourism industries [42]. This makes sustainable development in Macao less viable.

Considering the disadvantages of the heavy reliance on the gambling industry for economic development, the Macao government has realized the need for moderate economic diversification and is currently facilitating the development of other industries such as MICE, Traditional Chinese Medicine, Cultural and Creative Industries and featured financial services.

2.3. Agglomeration Economies

Agglomeration economies are the benefits that arise when firms and people are located near one another in cities and industrial clusters [43]. Marshall [44] pioneered this concept, suggesting that the benefits of agglomeration economies include labor market pooling, the sharing of inputs and knowledge spill-overs. Scholars after Marshall continued to conduct research on agglomeration economies. While most of the studies have focused on manufacturing industries [24,25], the benefits of agglomeration economies are similar across industries. They include the sharing of common resources (i.e., technology and labor), lower unit costs, better innovations for increasing returns to scale, proximity to suppliers and customers, knowledge spill-overs, enhancement of the strength of related clusters and the creation of new industries if there is a strong regional cluster [20–22,24,25,45].

The source of agglomeration is different between manufacturing industries and service industries [25]. The source of manufacturing industry agglomeration is the proximity to and concentration of supporting industries, while the source of service agglomeration is the proximity to and concentration of customers [25].

2.4. The Dilemma of Moderate Economic Diversification, Agglomeration Economies of Gambling Industry and Diminishing Returns in Macao

Because of its high concentration of casinos, Macao's economy is enjoying the benefits of agglomeration economies suggested by scholars in studies of other contexts. They include the concentration of customers, skilled labor and knowledge spill-over [25,45] and increase the strength of related agglomeration in the region [22]. The benefit of agglomeration economies suggests that over-adjustment of the gambling industry may harm the development of moderate economic diversification in Macao.

Apart from a concern about over-adjustment, the diminishing returns of the gambling industry in Macao may also be a concern. Delgado et al. [22] stated that "narrow regional specialization in an industry is likely to result in diminishing returns and the presence of unrelated economic activity is unlikely to significantly enhance opportunities for growth but may increase congestion." Applied to the context of Macao, the gambling industry may eventually lead to diminishing returns. Delgado et al.'s [22] findings imply that the development of the gambling industry in Macao may eventually reach a point of diminishing returns to scale, suggesting that the determination of an appropriate scale for gambling industry development is pertinent. The determination of an appropriate scale should strike a balance between the seemingly contradictory themes of continuous development without over-adjustment in the gambling industry and diminishing returns of that industry.

3. Research Methods

This study incorporated four steps: First, this study applied an entropy index of economic diversification to determine the levels of diversification of Macao economy. Second, the study adopted DEA to calculate the efficiency by a bootstrapping model to understand the efficiency of Macao's gambling industry. Third, the study derives the transition probability matrix of the three scenarios through interviews with native economic experts and the senior executives of large-scale gambling companies. Last, this paper employed the Markov chain to forecast the appropriate scale for Macao's gambling industry. This section introduces measuring methods, data source and chosen indicators.

3.1. Entropy Index of Economic Diversification

The measurement of diversification of Macao's economy is related to the measurement of the diversification of its industrial structure. Industrial structure refers to the constitution of each industry and the proportion of its added value in an economy. The industrial added value can be generally calculated by the producer's price (including product tax) and the basic price (not including the product tax). The franchise tax (part of product tax) of Macao's gambling industry should be considered part of the industrial total added value, because it is deducted from industrial total revenue or total turnover, generated from industrial economic activities that are not levied by extra ways and is regarded as a part of the output. Meanwhile, the gambling industry plays a leading role in Macao's economy and makes huge tax contributions, so calculating the gambling tax as an industrial output can more accurately reflect the proportion of the gambling industry in Macao's overall economic structure. From the viewpoint of appropriate diversification of Macao's economy development, the GDP calculated by the producer's price has a higher reference value than if it is calculated by the basic price in the input-output analysis. Thus, this study applied the industrial total added value (by producer's price) by chain price to calculate the entropy index of economic diversification.

The Entropy Index of Diversification (EID) [28] is one of the indicators that measures economic diversification in academia. Its calculation equation is

$$EDI = \sum_{i=1}^{N} S_i \ln\left(\frac{1}{S_i}\right) \tag{1}$$

In Equation (1), N is the number of industries; S_i is the proportion of added value of the ith industry of the total added value; and *ln* is the natural logarithm. If all added value is concentrated on one industry, the score of the entropy index is 0; with an increasing number of industries, the maximum score is $ln(N)$. Thus, a larger entropy index score refers to a higher level of economic diversification, while the smaller score reflects a relatively high level of economic concentration.

3.2. Data Envelopment Analysis (DEA)

This study applied the Data Envelopment Analysis (DEA) to measure the efficiency of Macao's gambling industry. DEA is a nonparametric frontier efficiency analysis that measures the production efficiency of the Decision-Making Unit (DMU). This model is applied to evaluate DMU's technology efficiency (TE) under the condition of constant returns to scale (CRS). Its basic premise is to assume that there are K DMUs including L input indicators and M output indicators that need to be evaluated. Then, the equation of the ith ($i = 1, 2, \ldots, K$) DMU's DEA model is

$$\min(\theta - \varepsilon(e_1^T s^- + e_2^T s^+));$$

$$\text{s.t.} \sum_{i=1}^{k} x_{il}\lambda_i + s^- = \theta x_l^n, l = 1, 2 \ldots, L; n = 1, 2 \ldots, K$$

$$\sum_{i=1}^{k} y_{im}\lambda_i - s^+ = y_m^n, m = 1, 2 \ldots, m; \lambda_i \geq 0.\ i = 1, 2 \ldots, K. \tag{2}$$

In Equation (2), θ is the TE value, $0 \leq \theta \leq 1$; ε is a dimensionless variable; s^- and s^+ values ≥ 0 are slack variables; e_1^T is an m dimension unit vector; e_2^T is a k dimension unit vector; $\lambda i \geq 0$ is the weighted variable; x_{il} is the lth ($l = 1, 2, \ldots, L$) recourse input of the ith DMU; and y_{im} is the mth ($m = 1, 2, \ldots, M$) output of the ith DMU. When production technology is considered under the condition of variable returns to scale (VRS), the constraint condition $\sum_{i=1}^{n} \lambda_i = 1$ is introduced into Equation (2) to get the DEA-BCC model (proposed by Banker, Charnes and Cooper) [29].

In conclusion, the DEA method fits the condition of *more input and more output* and does not need to set the functional forms of input variables and output variables. However, a study conducted by Simar and Wilson [46] revealed that both estimator $\hat{\theta}_{CCR}$ calculated by the CCR model (proposed by Charnes, Cooper and Rhodes) [47] and estimator $\hat{\theta}_{BBC}$ calculated by the BCC model are consistent under scenario of constant returns to scale (CRS). However, $\hat{\theta}_{BBC}$ has consistency while $\hat{\theta}_{CCR}$ does not under the scenario of variable returns to scale (VRS), which results in errors of calculation and goes against practical research. In view of this, studies by Zhang [48] and Yuan et al. [49] revealed that Macao gambling industry does not have constant returns to scale (CRS) and thus, this study only applied the DEA-BCC method and bootstrap method. In the following text, we describe the use of a bootstrapping-DEA model to attach more importance to the efficiency of Macao gambling industry as compared with a traditional DEA-BCC method to reveal its advantages or disadvantages.

The basic concept of the bootstrap method is obtaining a known sample $\theta_0 = (\theta_1, \theta_2, \ldots, \theta_K)$ from an unknown ensemble of probability distribution f by random sampling and then using a sample parameter $\hat{\boldsymbol{\varphi}} = \varphi(\theta_0)$ obtained from sample θ_0 to estimate the ensemble parameter $\varphi = \varphi(f)$. If the probability distribution of sample parameter $\hat{\boldsymbol{\varphi}}$ is unknown, it is necessary to use an empirical density function with a sample parameter simulated by bootstrap repeated sampling to judge the error between ensemble parameter φ and sample parameter $\hat{\boldsymbol{\varphi}}$. Based on the premise of bootstrap, steps of bootstrapping-DEA are as follows:

Step 1: Based on each DMU's input–output set (X_i, Y_i), $i = 1, 2, \ldots, K$, get the initial efficiency score $\hat{\boldsymbol{\theta}}_{\boldsymbol{i}}$, consisting of a set $\hat{\boldsymbol{\theta}}_{\boldsymbol{0}} = (\hat{\boldsymbol{\theta}}_{\boldsymbol{1}}, \hat{\boldsymbol{\theta}}_{\boldsymbol{2}}, \ldots, \hat{\boldsymbol{\theta}}_{\boldsymbol{K}})$ of efficiency scores of all Decision Making Units;

Step 2: Apply the smoothing bootstrap method to get a bootstrap sample $\boldsymbol{\theta}^*_{\boldsymbol{1b}} = (\boldsymbol{\theta}^*_{\boldsymbol{1b}}, \boldsymbol{\theta}^*_{\boldsymbol{2b}}, \ldots, \boldsymbol{\theta}^*_{\boldsymbol{Kb}})$ by repeated sampling from the efficiency score sample $\hat{\boldsymbol{\theta}}_{\boldsymbol{0}} = (\hat{\boldsymbol{\theta}}_{\boldsymbol{1}}, \hat{\boldsymbol{\theta}}_{\boldsymbol{2}}, \ldots, \hat{\boldsymbol{\theta}}_{\boldsymbol{K}})$; b refers to b iterations by using the bootstrap method;

Step 3: Based on the smoothing bootstrap efficiency set $\boldsymbol{\theta}^*_b = (\boldsymbol{\theta}^*_{\boldsymbol{1b}}, \boldsymbol{\theta}^*_{\boldsymbol{2b}}, \ldots, \boldsymbol{\theta}^*_{\boldsymbol{Kb}})$ estimated by Step 2 and under conditions of constant output, adjust the initial input variable X_{i} and then get $\boldsymbol{X}^*_{\boldsymbol{ib}} = (\hat{\boldsymbol{\theta}}'_{\boldsymbol{i}}, \boldsymbol{\theta}^*_{\boldsymbol{ib}}) \times X_i$, $i = 1, 2, \ldots, K$;

Step 4: Based on the adjusted input-output amount $(\boldsymbol{X}^*_{\boldsymbol{ib}}, \boldsymbol{Y}_{\boldsymbol{i}})$, $i = 1, 2, \ldots, K$, use the DEA method to compute each DMU's efficiency score $\boldsymbol{\theta}^*_{\boldsymbol{1b}}$ again;

Step 5: Repeat Steps 2 to 4 B times and then get a series of efficiency scores $\boldsymbol{\theta}^*_{\boldsymbol{1b}}$, $b = 1, 2, \ldots, B$;

Step 6: Compute the error $\overline{\mathbf{Bias}}\,(\hat{\boldsymbol{\theta}}_i)$ of the initial efficiency score $\hat{\boldsymbol{\theta}}_{\boldsymbol{i}}$ of each DMU and the adjusted efficiency score $\widetilde{\boldsymbol{\theta}}_{\boldsymbol{i}}$ after error correcting:

$$\overline{\mathrm{Bias}}(\hat{\theta}_i) = \boldsymbol{B}^{-1}\sum\nolimits_{\mathrm{b}=1}^{\mathrm{B}}(\hat{\theta}^*_{ib}) - \hat{\theta}_i,$$

$$\widetilde{\boldsymbol{\theta}}_{\boldsymbol{i}} \;=\; \hat{\boldsymbol{\theta}}_{\boldsymbol{i}} - \overline{\mathbf{Bias}}(\hat{\boldsymbol{\theta}}_{\boldsymbol{i}}) \;=\; 2\hat{\boldsymbol{\theta}}_{\boldsymbol{i}} - B^{-1}\sum\nolimits_{\mathrm{b}=1}^{\mathrm{B}}(\hat{\theta}^*_{ib})$$

Step 7: Calculate the confidence interval of the adjusted efficiency score $\widetilde{\theta}_i$ after error correcting the confidence level α. The confidence interval of the adjusted efficiency score $\widetilde{\theta}_i$ after error correcting is $P_r(-\hat{b}_\alpha \le \hat{\boldsymbol{\theta}}^*_{\boldsymbol{ib}} - \hat{\theta}_i \le -\hat{a}_\alpha) = 1 - \alpha$ and furthermore, we have $\hat{\theta}_i + \hat{a}_\alpha \le \widetilde{\theta}_i \le \hat{\theta} + \hat{b}_\alpha$.

The bootstrapping-DEA model can avoid issues like having a small-sized sample, sample sensitivity and outliers, rectify the offsetting of the efficiency score and make up for the shortcomings of the traditional DEA method. The small economy size and incomplete economic industry in Macao result from difficulty getting relevant data. The bootstrapping-DEA model can solve the problem of having insufficient samples by repeated sampling so that the actual efficiency and future development tendency can be better analyzed.

3.3. Markov Chain Forecast

The Markov chain, a widely used random process model, involves the quantitative analysis of a system's status transformation that can be transferred with time and has the property of probability, which allows it to consider the influences of previous events on later events. The Markov chain forecast method predicts laws of development of systematic dynamic data in the light of probability of status transformation and fits issues to a forecast with big random fluctuations but requires the objects being forecasted to have the characteristics of a Markov chain as well as being a mean value-like stable process. A Markov chain forecast has to establish a systematic status transition probability matrix, which can be estimated by a market survey, expert interview and regression model. Let us respectively assume that $x_2, \ldots\ x_n$ and $E = \{1, 2, \ldots, m\}$ are a series of index sequence values of the Markov chain and the status space of the Markov chain.

Let us compute the distribution vector in the initial status to form the state vector and then calculate sequential values of the indicator through a transition matrix step, using f_{ij} to refer to times when status i transfer to status j, $i, j \in E$. In practical applications, only one step transition probability matrix is considered. Matrix $(f_{i,j})_{i,j\in E}$, constituted by f_{ij} $(i, j \in E)$, is named the status transition probability matrix. The transition probability is the value that divides every matrix element by the sum of each row it is in and can be referred to as P_{ij} $(i, j \in E)$. The equation is

$$P_{ij} = \frac{f_{ij}}{\sum_{j=1}^{m} f_{ij}}. \tag{3}$$

A Markov chain model is used to forecast, while χ^2 can be used to test whether the random variable sequence of the system has the Markov property. The times that the sequential value of indicator transfers from status i to status j through a one-step transition matrix can be referred to as f_{ij}, $i,j \in E$ and then we can get the system's marginal probability, the equation of which is

$$P_j = \frac{\sum_{i=1}^{m} f_{ij}}{\sum_{i=1}^{m}\sum_{j=1}^{m} f_{ij}}. \tag{4}$$

It is the sum of elements in the jth column divided by the sum of all elements in the state transition frequency matrix. When n is large enough, $x^2 = 2\sum_{i=1}^{m}\sum_{j=1}^{m} f_{ij} = \left|\log \frac{p_{IJ}}{p_J}\right|$ obeys the distribution of x^2 at the free degree of $(m-1)^2$. If the x^2 value is larger than the value of $x^2_\alpha(m-1)^2$, the sequence has the Markov property. Otherwise the sequence cannot be forecast by the Markov chain.

Forecasting the development tendency of Macao's gambling industry by applying the Markov chain and researching features of Macao's industrial structure has strong practical significance. Since the Markov chain forecasting method has significant support for short-term research and relatively strong sensitivity to short-term change, this method was chosen to forecast changes in Macao's industrial diversification.

3.4. Data Collection and Variables Description

This study calculated the entropy index of economic diversification based on the chain volume measures (2015) of total added value (producer price) of 16 industries in Macao from 2008 to 2016. Relevant data are from the Statistics and Census Service of the Government of Macao Special Administrative Region.

This study calculated the DEA efficiency of the gambling industry in Macao from 2008 to 2016, setting years as the Decision-Making Units (DMU) and adopting DEA efficiency calculated by a bootstrapping model to discover the change of efficiency of the gambling industry in Macao. In this study, input variables are the numbers of casinos (order of magnitude is 1), gambling tables (order of magnitude is 1), hotel rooms (order of magnitude is ten thousand) and employees (order of magnitude is ten thousand). These input variables reflect the scale of the gambling industry. To be specific, the number of casinos, amount of gambling tables, number of hotel rooms and the number of employees reflect land, capital and human investments. As a small economy, land, capital and human resources are the main inputs of Macao economic development. Output variables include the gambling gross income (order of magnitude is 100 million MOP), the gambling tax revenue (order of magnitude is 100 million MOP) and the GDP (order of magnitude is 100 million MOP). The gambling gross income and gambling tax revenue are good measurements of the gambling industry's outcome. Since gambling tax revenue accounts for a high proportion of Macao GDP, GDP is also used as a measurement of the gambling industry's outcome.

4. Results

4.1. Entropy Index of Economic Diversification

This study calculated the entropy index of economic diversification based on the chain volume measures of the total added value (producer price) of 16 industries in Macao in 2015. Table 1 and Figure 1 illustrate the results of the revealed relevant calculation.

Table 1. Macao entropy index of economic diversification.

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016
Entropy index of economic diversification	2.04	1.99	1.74	1.60	1.60	1.58	1.68	1.97	2.02

Comment: results were calculated by the chain price (2015) of the main industries' total added value (producer's price). Data source: Statistics and Census Service of the Government of Macao Special Administrative Region.

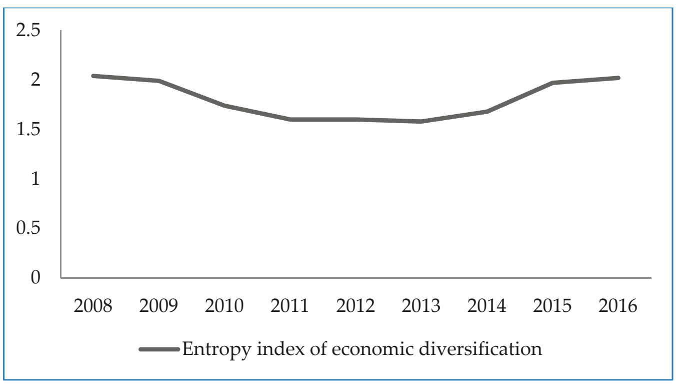

Figure 1. Macao entropy index of economic diversification.

According to the results, Macao's industrial diversification continuously decreased from 2008 to 2013, while Macao's gambling industry developed rapidly after it opened. However, it started to change in 2014. In 2015, the gross income of the gambling industry had declined by 34.3%, which resulted in a rise in the entropy index of economic diversification calculated by the industrial added value. Therefore, once industrial concentration shows a slight decline, the industrial structure is more diversified.

4.2. Bootstrapping-DEA Efficiency

To understand Macao's gambling industry's efficiency, the efficiency of bootstrapping-DEA based on variable returns to scale (VRS) was calculated. Table 2 demonstrates the results of bootstrapping-DEA efficiency. Figure 2 illustrates the gambling industry's efficiency along with the economic diversification in Macao from 2008–2016.

Table 2. Gambling industry's efficiency and economic diversification in Macao.

Year	DEA-BCC Efficiency	Bootstrapping-DEA Efficiency	Entropy Index of Economic Diversification
2008	0.68648	0.60396	2.04
2009	0.61839	0.56198	1.99
2010	0.82248	0.73357	1.74
2011	0.99921	0.92339	1.60
2012	0.91766	0.89850	1.60
2013	1.00000	1.00000	1.58
2014	1.00000	1.00000	1.68
2015	0.81936	0.81762	1.97
2016	0.83262	0.83097	2.02

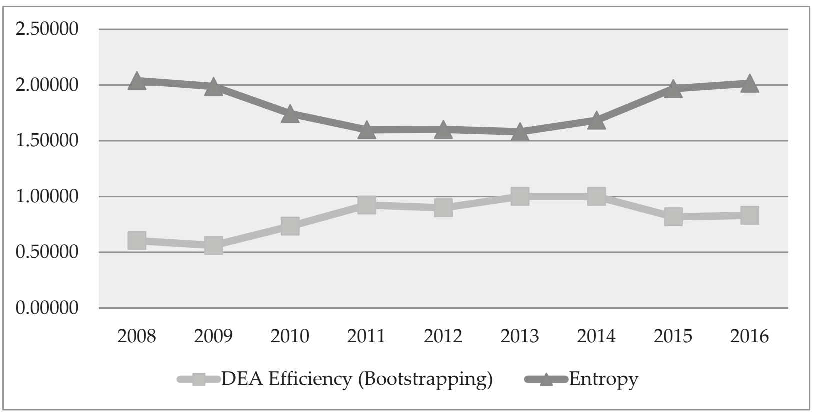

Figure 2. The gambling industry's efficiency and economic diversification in Macao.

Figure 2 show the bootstrapping-DEA efficiency and entropy index of economic diversification from 2008 to 2016. In terms of the gambling industry's efficiency, both the traditional DEA-BCC efficiency and bootstrapping-DEA efficiency of Macao's gambling industry in 2016 were less than 1. Both the DEA-BCC efficiency and bootstrapping-DEA efficiency were 1 in 2013 and 2014. However, the DEA-BCC efficiency and bootstrapping-DEA efficiency showed big differences from 2008 to 2011. Bootstrapping-DEA was less efficient than DEA-BCC from 2008 to 2011. The bootstrapping-DEA efficiency is more efficient because it reduces errors by repeated sampling.

4.3. Transition Matrix According to Relatedness and Complexity Framework

Table 3 shows the transition matrix based on the expert interviews. Here are the basic assumed conditions of the Markov chain process: the number of system states in the forecast period remains constant; the system state transition probability matrix will not change over time; and the state transition is only affected by the previous state, namely the non-aftereffect property. A Markov chain is a Markov process with a discrete time and discrete state. In a Markov chain, the transition of system state needs a probability matrix. The probability of a state at any later time point can be forecasted by the probability of states at initial time points through the state transition probability matrix. Thus, this study reaches the transition matrix in Table 3 through interviews with native economic experts and the senior executives of large-scale gambling companies to derive the transition probability matrix of the three scenarios in Table 3, namely, rapid transition from the gambling industry to the non-gambling industry, stable transition from the gambling industry to the non-gambling industry and slow transition from the gambling industry to the non-gambling industry.

Table 3. Transition probability matrix based on expert interviews.

	Scenario 1: Rapid Transition from the Gambling Industry to the Non-Gambling Industry (High Relatedness Diversification Transition)		Scenario 2: Stable Transition from the Gambling Industry to the Non-Gambling Industry		Scenario 3: Slow Transition from the Gambling Industry to the Non-Gambling Industry (Technology-Oriented Diversification)	
	Gambling Industry	**Non-Gambling Industry**	**Gambling Industry**	**Non-Gambling Industry**	**Gambling Industry**	**Non-Gambling Industry**
Gambling industry	92.0%	8.0%	95.6%	4.4%	98.0%	2.0%
Non-gambling industry	0.5%	99.5%	0.5%	99.5%	0.5%	99.5%
Economic growth rate			7%			

As shown by the probability results in Table 3, when the gambling industry stably transfers to the non-gambling industry, in the following year, the probability that the gambling industry transfers to the non-gambling industry is 8% and the probability that it remains there is 92%; the probability that the non-gambling industry transfers to the gambling industry is 0.5% and the probability that it remains there is 99.5%.

4.4. Forecast by the Markov Chain

This study applies the ring price in 2015 to calculate a total added value (based on the producer's price and one million Macao dollars per unit) of 16 industries in Macao and the proper scales and growth rates of Macao's gambling industry and non-gambling industry were forecast until 2021 through the forecast model of the Markov chain. The situation at the initial time points was that the gambling industry's total output value was much larger than the non-gambling industry's total output value. Table 4 shows the relevant results under the assumption that the gambling industry transfers to the non-gambling industry through a state transition probability matrix.

Table 4. The scales and growth rates for Macao's gambling industry and non-gambling industry forecasted by the Markov chain in three scenarios (unit: million Macao dollars).

	Scenario 1: Rapid Transition from Gambling Industry to Non-Gambling Industry (High Relatedness Diversification Transition)				Scenario 2: Stable Transition from Gambling Industry to Non-Gambling Industry				Scenario 3: Slow Transition from Gambling Industry to Non-Gambling Industry (Technology Oriented Diversification)			
	Gambling Industry		**Non-Gambling Industry**		**Gambling Industry**		**Non-Gambling Industry**		**Gambling Industry**		**Non-Gambling Industry**	
2008	105,717	%	141,340	%	105,717	%	141,340	%	105,717	%	141,340	%
2009	112,708	6.6	134,009	−5.2	112,708	6.6	134,009	−5.2	112,708	6.6	134,009	−5.2
2010	173,772	54.2	135,239	0.9	173,772	54.2	135,239	0.9	173,772	54.2	135,239	0.9
2011	231,704	33.3	145,158	7.3	231,704	33.3	145,158	7.3	231,704	33.3	145,158	7.3
2012	252,773	9.1	158,832	9.4	252,773	9.1	158,832	9.4	252,773	9.1	158,832	9.4
2013	287,099	13.6	174,450	9.8	287,099	13.6	174,450	9.8	287,099	13.6	174,450	9.8
2014	265,689	−7.5	186,168	6.7	265,689	−7.5	186,168	6.7	265,689	−7.5	186,168	6.7
2015	171,105	−35.6	185,085	−0.6	171,105	−35.6	185,085	−0.6	171,105	−35.6	185,085	−0.6
2016	165,094	−3.5	191,126	3.3	165,094	−3.5	191,126	3.3	165,094	−3.5	191,126	3.3
2017	163,541	−0.9	217,614	13.9	169,900	2.9	211,255	10.5	174,140	5.5	207,015	8.3
2018	162,154	−0.8	245,682	12.9	174,925	3.0	232,911	10.3	183,711	5.5	224,125	8.3
2019	160,939	−0.7	275,446	12.1	180,180	3.0	256,205	10.0	193,838	5.5	242,547	8.2
2020	159,902	−0.6	307,030	11.5	185,681	3.1	281,251	9.8	204,556	5.5	262,375	8.2
2021	159,050	−0.5	340,567	10.9	191,441	3.1	308,176	9.6	215,902	5.6	283,715	8.1
Entropy Index of Economic Diversification (2021)												
	2.01				1.84				1.70			

The appropriate scales for Macao's gambling industry and non-gambling industry in 2021 were forecast by the Markov chain. Under scenario 1 referred to Figure 3, the industrial added value of the gambling industry is predicted to be 159.050 billion Macao dollars and the industrial added value of the non-gambling industry is predicted to be 340.567 billion Macao dollars. The growth rates for gambling and non-gambling industry are −0.5% and 10.9% respectively. The economic diversification entropy index is predicted to be 2.01.

Under scenario 2 referred to Figure 4, the gambling industry moves smoothly to the non-gambling industry. In 2021, the industrial added value of Macao's gambling industry is predicted to be 191.441 billion Macao dollars, the industrial added value of the non-gambling industry is predicted to be 308.176 billion Macao dollars, the growth rates for gambling and non-gambling industry are 3.1% and 9.6% respectively and the economic diversification entropy index is predicted to be 1.84.

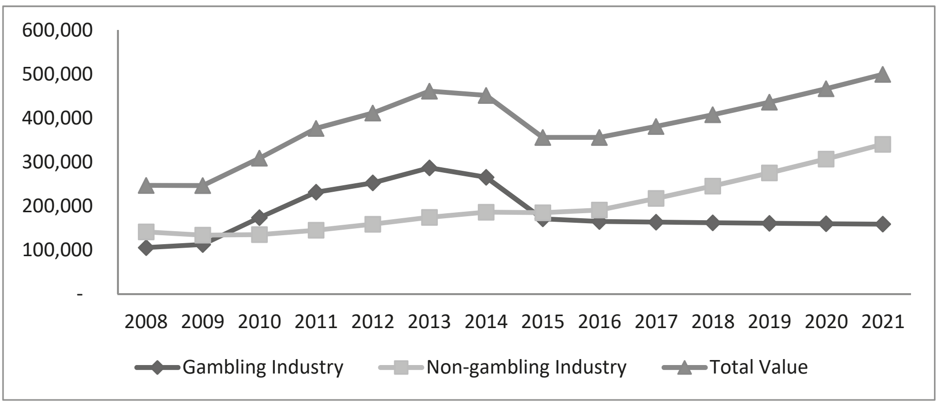

Figure 3. The scale for Macao's gambling industry forecast by the Markov chain—scenario 1.

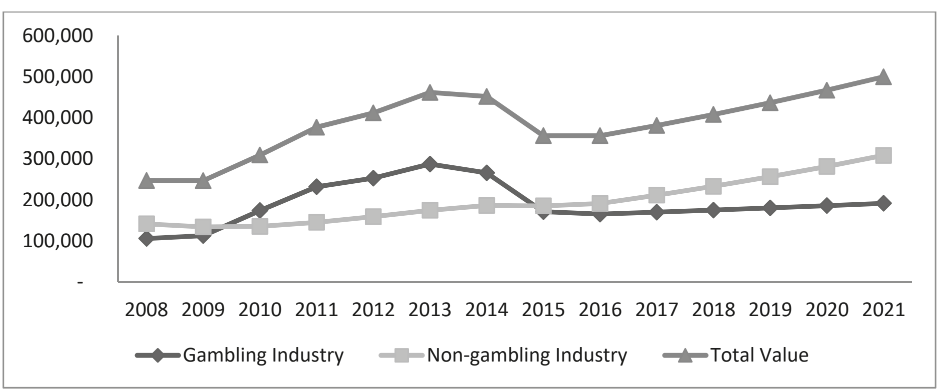

Figure 4. The scale of Macao's gambling industry forecast by the Markov chain—scenario 2.

Under scenario 3 referred to Figure 5, the gambling industry slowly moves to the non-gambling industry. In 2021, the industrial added value of the Macao's gambling industry is predicted to be 215.902 billion Macao dollars and the industry added value of the non-gambling industry is predicted to be 283.715 billion Macao dollars. The growth rates for gambling and non-gambling industry are 5.6% and 8.1% respectively. The economic diversification entropy index is predicted to be 1.70. Under the three scenarios, the overall added value of Macao is continuously increasing.

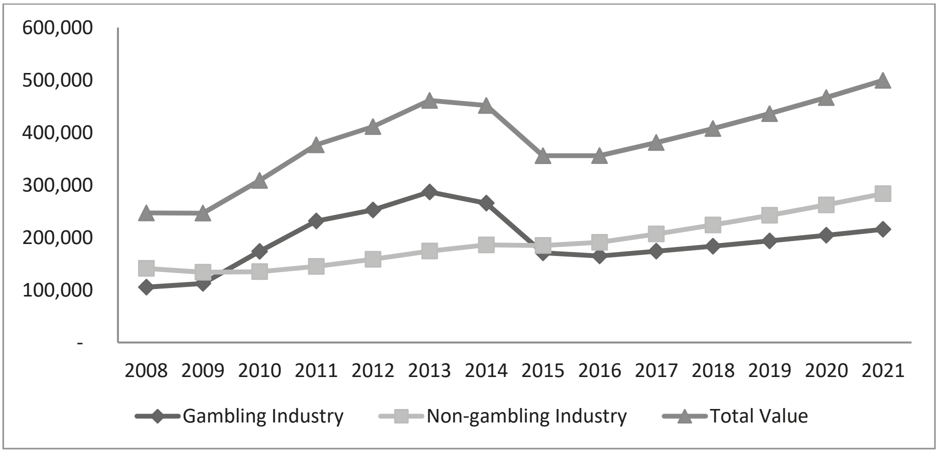

Figure 5. The appropriate scale of Macao's gambling industry forecasted by the Markov chain—scenario 3.

5. Discussion

The entropy index of economic diversification in Macao, which was calculated in Section 4.1, was 1.99 in 2009. According to Measuring Economic Diversification in Hawaii [17] published by the Department of Business, Economic Development and Tourism of Hawaii in 2011, the entropy index of economic diversification of Hawaii, which positions tourism as its pillar industry, was 2.61 in 2009, while the value of the same index in the state of Nevada, home to Las Vegas, which positions gambling as its pillar industry, was 2.64. Both of these relevant index values are higher than Macao's, which means their level of economic diversification is higher than Macao's. From the empirical calculation of the entropy index of economic diversification and the comparison to Hawaii and Nevada, which have mainstay industries of gambling and tourism, respectively, Macao is revealed to have a relatively high industrial concentration and insufficient industrial diversification.

The calculation of efficiency by bootstrapping-DEA based on VRS is more accurate than efficiency calculated by the traditional BCC-VRS model, because the traditional DEA method has an advantage in parameter estimation. However, the traditional DEA method may bias the sample evaluation so that the statistic test is ignored. A bootstrapping-DEA model can make up for the traditional DEA method's deficiency by simulating the process of data generation through repeated sampling to fix the bias in the sample evaluation results. This study shows that the bootstrapping-DEA efficiency computed by repeated sampling calculation is more accurate than the efficiency computed by the traditional BCC-VRS model. Bootstrapping-DEA takes statistical tests into consideration so that bias resulting from sample evaluation is avoided.

This result is consistent with actual observations. During the gambling industry depression that began in 2015, the central government of China had adjusted the number of visitors to Macao, which resulted in the decline of gambling tax revenue. When gambling tax revenue declined, the level of Macao's economic diversification improved to some degree. Therefore, it is necessary to transfer the gambling industry's added value to the non-gambling industry.

6. Conclusions

6.1. Summary and Implications

The principle of determining an appropriate scale for Macao's gambling industry is based on the premise of achieving appropriate diversification in Macao's economy. The gambling industry is the dominant industry in Macao. The goal of achieving appropriate industrial diversification in

Macao is associated with issues about scale and efficiency in the gambling industry. Therefore, we need to calculate the efficiency of the gambling industry by a bootstrapping-DEA model based on VRS. In terms of the gambling industry's efficiency, in 2016, both the traditional DEA-BCC efficiency and the bootstrapping-DEA efficiency of the gambling industry were less than 1, which reveals insufficient efficiency in the operation of the gambling industry. In 2013 and 2014, both the DEA-BCC efficiency and the bootstrapping-DEA efficiency were 1, which means Macao's gambling industry was efficient in these two years. However, the DEA-BCC efficiency and bootstrapping-DEA efficiency showed big differences from 2008 to 2011.

Through the Markov chain forecast, the quantitative gambling industry scale for the goal of appropriate economic diversification can be given. The appropriate scales for Macao gambling industry and non-gambling industry in 2021 were forecast by a Markov chain. Under the three scenarios, the overall added value of Macao was predicted to continuously increase. Under scenario 1, although the entropy index of economic diversification is high and the growth rate for non-gambling industry is above 10%, the growth rate for gambling industry is negative. Therefore, rapid transition causes an issue of sustainable growth for the gambling industry. Under scenario 3, when the growth rate of gambling is around 5.5%, the growth rate of non-gambling is around 8.2%. This growth rate is lower than the growth rates in 2012 and 2013. The slow transition does not provide a satisfying economic diversification. Under scenario 2, the gambling industry is smoothly transferred to the non-gambling industry. In 2021, in case the growth rate of gambling is around 3%, an economic diversification entropy index of 1.84 will be more suitable for the actual situation that the growth rate for non-gambling industry is around 10%.

6.2. Theoretical Contributions

The results of this study make the following three theoretical contributions. First, according to the Chicago School of Industrial Economics Theory, the larger the scale of an industry, the higher its efficiency and innovation ability [50] but the sustainable development theory puts limits the growth. Macao is a small economy. The gambling industry dominates more than half of the whole economy. It has negative externalities, so it is easily affected by the external environment and has a siphon effect on other industries. Therefore, the continuous expansion of the gambling industry is unsustainable for the industry itself and the overall economy and society. Macao and some other international cities that position gambling and tourism as a pillar industry has always advocated for moderate diversification of the industry. Therefore, this study discusses how to assess the achievement of a moderately diverse economy in a small economy and how to obtain quantitative and appropriate scales to achieve economically sustainable development in the small economy.

Second, this study confirms that the scale of the current gambling industry in Macao is in line with the theory of congestion of production factors, which states that overdevelopment of a dominant industry will reduce its own efficiency and harm the development of other industries [51]. In recent years, the scale of the gambling industry has expanded and its efficiency has declined. This study shows that controlling the gambling industry in an appropriate scale can improve its efficiency. This study also shows that a stable transition from gambling industry to non-gambling industry can achieve a moderate economic diversification.

Finally, Macao needs to have sustainably economic diversification including the sustainable development of the gambling industry. Economic diversification aims to speed up the growth of economic outputs from a range of industries. It leads to a consequence of long-term economic growth which provides economic well-being in much longer-term through the notion of economic sustainability. For having economic sustainability, economic diversification is not just the economic development of certain industries. It involves technical and institutional arrangements by which output is produced and distributed [52]. Thus, we need to determine how to influence the other industries under the premise of sustainable development of the gambling industry. To develop a robust and stable economy, Macao's gambling industry should appropriately adjust its scale and diversify as much as possible to adjust to the development status that is most suitable to achieve sustainable development and the continued development of other industries. This study contributes to sustainability study a model that can be used to reveal the optimal level of development of gaming industry in order to create conditions for economic diversification in Macao. This model can also be used to calculate the appropriate scale for one industry to optimally develop economic diversification in other cities.

6.3. Practical Implications

With regard to the sustainable development of the gambling industry, continuous expansion of the scale of the gambling industry cannot result in sustainable high efficiency. The gambling industry experienced more production costs in 2016 and its scale in 2016 was larger than its scale in 2013 or 2014, while its efficiency in 2016 was lower than its efficiency in 2013 or 2014, which means that there was a waste of resources. Thus, government officials and casino operators should pay more attention to the improvement of the gambling industry's efficiency. For instance, the number of gambling tables in Macao was 5700–5800 in 2013 and 2014 and 6287 in 2016 but the efficiency in 2016 was not as high as in 2013 and 2014. There was a waste of resources. The casino operators should put more efforts to increase their efficiency and not just look for enlarging their market shares. For example, the casino operators could combine gambling with other cultural and entertainment industries to increase the overall efficiency.

In terms of policy about the gambling industry's sustainable development, from 2016 to 2017, the Macao SAR government first proposed a specific indicator that the growth rate of total number of gambling tables in the ten years after 2013 should be no more than 3% and that the addition of new gambling tables should be strictly regulated to adjust the gambling's industry scale. However, this study has found that this policy failed to achieve the goal of regulating Macao's gambling industry scale to make the industry appropriately diversified. This study reveals a new understanding that there must be a significant transition of the gambling industry economy to the non-gambling industry economy to achieve a moderately diversified economy. The local government should consider imposing certain requirements facilitating economic diversification when issuing casino licenses in the coming years.

According to the results of this study, under Scenario 2, for the gambling industry to move smoothly to non-gambling industries, the Macao government should slash the added value of the gambling industry and increase the added value from non-gambling industries. In addition to developing industries related to gambling and tourism for diversifying tourists' consumption options [53], it is necessary to develop a platform for innovation and technology development. However, given Macao has a land area of just 30.8 km^2, with much of the land being occupied by gambling operators [54], where and how to develop the platform for diversifying its economic structure will be a challenge for the Macao government.

6.4. Limitation and Further Studies

This study has some limitations. First, although a transition matrix forecast by a Markov chain was specified by this study, the relevant probability of the transition matrix needs further research, for example, through interviews with experts from neighboring areas or by conducting a questionnaire survey. In addition, more diversified input indicators, for example, the number of slot machines and casino acreage, could be added into the bootstrapping-DEA model as variables. Last, future research needs to pay more attention to the methods and policies of increasing the non-gambling industry's added value.

In a small economy like Macao, the gambling industry dominates the whole economy. The gambling industry alone occupies more than 50% of Macao GDP on average. Therefore, the degree of diversity is high only when the income of the gambling industry is reduced. This is because the income of the gambling industry is highly related to the index of diversity. However, the efficiency of gambling industry is calculated from its input-output. So, the index of diversity cannot be used to determine the relationship between the efficiency of the gambling industry and diversification. The future study is recommended to evaluate any relationship between the input of gambling industry and the diversity of the overall economy.

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Article

Insufficient Consumption Demand of Chinese Urban Residents: An Explanation of the Consumption Structure Effect from Income Distribution Change

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Abstract: China's consumption rate has continued to decline since 2000, which has retarded the sustainable growth of China's economy. The dramatic changes in China's income distribution have been very significant social characteristics, and they are also a very important factor for consumption. Therefore, this study analyzes the problem of insufficient domestic demand from the perspective of the effects of the income distribution changes on the consumption structure. The Almost Ideal Demand System model is improved by relaxing its assumption that expenditure equals income and giving it a dynamic form that includes the three characteristics of the income distribution evolution (the mean, variance, and residual effects) and measuring these. The results show that the mean effect is the largest one, and it basically determines the size and direction of the total effect. The variance effect is much smaller, but it may have some positive effects on the individual markets. The residual effect is the smallest and has a certain randomness. The income gap is not the main cause of the insufficient domestic demand. It is more likely to be caused by the decline of the mean effect, and the main driver of this is the irrationality of the supply side and excessive housing prices.

Keywords: insufficient demand; income distribution change; demand structure effects; AIDS model; counterfactual decomposition

1. Introduction

Since the reform in 1978, China's economy has experienced nearly 30 years of rapid growth. According to the data from the National Bureau of Statistics of China [1], China's per capita GDP growth rate was 8.4% from 1978 to 1999, and per capita GDP reached $840 in 1999, marking the entry of middle and lower income countries. From 2000 to 2010, the average annual growth rate of per capita GDP was 9.7%, and per capita GDP rose to $4240, successfully ranking among the upper and middle income countries. But since 2011 the previous investment and external trade-oriented development pattern seems to have reached its limitation. Similar to the typical stagnant growth countries in Latin America and emerging economies in Southeast Asia, such as Malaysia, the Philippines, and Thailand, which is known as the "middle income trap" [2]. China's economic growth has also slowed down. From 2011 to 2018, GDP growth rates were 9.5%, 7.8%, 7.7%, 7.3%, 6.9%, 6.7%, 6.9%, and 6.6%, respectively. Therefore, the Chinese government announces that China's economy has shifted from high-speed growth to a "new normal" dominated by medium- and high-speed growth, and scholars become more concerned about the future trend of China's economy and its sustainability. The core issue is whether the Chinese economy will further decline and when it can successfully cross the "middle income trap".

In fact, one of the fundamental reasons for being trapped in the "middle income trap" is that, after a country has completed rapid development from a low-income level to a middle-income level, the internal structure of its economic system has not been optimized autonomously with the improvement of production levels, making endogenous growth factors unable to support economic development to a higher level. Therefore, the essence of the "middle income trap" is a problem of the transformation of economic growth mode. The key to crossing the "middle income trap" is to find new combinations of economic growth factors and improve the structural quality of the economic system. As the ultimate goal of social production, consumer demand plays an exceptional role in the process of transformation [3].

Firstly, after reaching the middle income level, labor factor as one of the three basic factors is the key to optimize the combination of factors and ultimately improve the efficiency and quality of economic growth. The improvement of consumption level reflecting the living standard of residents can improve the overall quality of labor force from many aspects. The corresponding technological innovation will also increase with the improvement of the quality of labor force, which will produce a qualitative leap in the productivity of input factors, effectively promote supply-side reform, and provide a source of power for economic growth. Secondly, the continuous upgrading of industrial structure is an important part of the transformation process of economic growth mode. The improvement of consumption level puts forward higher requirements for product quality and supply structure, which can play a guiding role in the optimization and upgrading of industrial structure and improve the quality of economic growth. Finally, the consumption-oriented mode can guide the optimal allocation of resources, improve the level of marketization, make social distribution more equitable and reasonable, and ultimately promote the sustained and healthy growth of the economy.

Moreover, the international experience of economic development has also fully affirmed the role of consumer demand in driving economic growth. Saito [4] and Horioka [5] studied the causes of Japan's economic slowdown, and found that insufficient consumption was an important factor in slowing down economic growth. At the same time, from the economic performance of developing countries after 1956, the degree of attention to consumption largely determined the economic development speed of each country. Munir and Mansur [6] theoretically proved that the improvement of consumption level, as one of the driving forces of GDP growth, can promote the growth of a country's economy. Using international data starting in 1957, Eichengreen et al. [2] construct a sample of cases where fast-growing economies slow down. Their results suggest that a low consumption share of GDP is positively associated with the probability of a slowdown, although there is no iron law of slowdowns. Liu and Wang [7] based on 32 samples from developed and developing countries, using panel smoothing transfer regression model, obtained a consumption rate of 68.12% which is most conducive to promoting economic growth.

Chinese government is also gradually realizing the importance of consumption to long-term sustainable economic growth [8], with the emergence of overcapacity, a slowdown in growth, and a series of other developmental problems. Unfortunately, China is also facing a big consumption problem, that is, insufficient domestic demand. According to the World Bank's World Development Indicators [9], China's final consumption rate reached 63.6% in 2000, close to Liu's optimal level [7], but then continued to decline to 48.1% in 2010. Although it has improved since 2011, it has only increased to 52.6% by 2017, which is far below the theoretical optimum level. Excluding government consumption, the resident consumption rate has also continued to decline since 2000 from 46.7% to its lowest point of 35.6% in 2010, although the recent rate has rebounded but only minimally. The Chinese government has called for rebalancing the economy towards greater reliance on consumption as the driver of growth and implemented a series of positive policies to expand domestic demand, but so far these have had little effect. So, the main purpose of this paper is to analyze the internal mechanism of why China's consumption demand has not fully promoted economic growth.

Further, in sharp contrast to the lack of consumer demand, there has been a series of consumer booms in single markets, such as real estate, cars, Apple mobile phones, and other high-tech digital products, and Chinese consumers have been eager to purchase some goods that are booming overseas, so inadequate domestic demand is not the whole question; Chinese residents still have a strong consumer potential. We see a "lack of overall demand but strong local demand" coexistence phenomenon. So, we believe that there are certainly deeper reasons for the special economic operation phenomenon caused by the accumulation of deep-seated flaws in China's economic growth.

The most direct way to stimulate consumption is to increase residents' income, but the unequal promotion will widen the income gap and is not conducive to consumption. The drastic change in income distribution of billions of people is a significant special factor that distinguishes China from other countries. The income distribution here refers not only to the income gap that can be expressed by variances but also to the whole income distribution curve characteristics such as mean, skewness, and kurtosis. Moreover, the successful experience of Korea and Japan in crossing the "middle income trap" tells us that the formation of stable, reasonable and strong consumer demand is inseparable from the sustained growth of household income and reasonable income distribution [5,10]. Therefore, the final specific research objective is to study the impact of income distribution changes on the consumption structure.

Based on the perspective of the income distribution change, this study holds that the above-mentioned "lack of overall demand, but strong local demand" that coexists with the consumption structure problem is mainly caused by the imbalance between the demand structure and the supply structure, and the rapid evolution of the demand structure is the dominant factor in this contradiction. The effects of the three dynamic characteristics of the income distribution on the consumption demand structure are called the mean effect, variance effect, and residual effect, respectively. The mean effect mainly reflects the effect of the overall income level on the whole consumption structure. The variance effect and the residual effect collectively reflect the effect of the income gap on the consumption demand. However, the residual effect reflects a symmetry heterogeneity effect that is caused by the differences of region and human capital. This study calls them "the demand effects of residents' income distribution change."

In the perspective of income distribution changes, the question of how to expand the domestic demand and realize the transformation of economic growth driven by consumption is transformed into the question of how to form a reasonable consumption structure, which is, of course, affected by the change in the income distribution. Accordingly, once the relationship between the income distribution and consumption structure is sorted out, the problem of insufficient demand can be solved at the source, which is of great significance to the structural reform and sustainable growth of China's economy.

The rest of this paper is as follows. The second section is about review of literature. The third section is the derivation of the AIDS dynamic expansion model. The fourth section is the description of the data and construction of the indicators; the consumption and income data related to the urban residents in the Chinese Statistical Yearbook are selected. The fifth section is the empirical test, where the influence of income changes on the consumption demand structure is measured and discussed. The sixth Section gives the conclusions and the consequent policy recommendations.

2. Review of Literature

There are many explanations for the root causes of China's insufficient domestic demand, and one of these is the mainstream view that says the problem can be attributed to the Chinese residents' high and rising savings. The research [11–13] on this explanation suggests that China's economic structure is in rapid change, and the urban and rural social security system is not perfect, so there is uncertainty about personal future income and expenditure thereby causing residents to require precautionary savings. But Aziz and Cui [14] suggest that the increase in saving alone explains only a small fraction of the decline in the consumption share; in their view a much larger cause of the problem has been the role of the declining share of household income in the national income.

Another popular view is that the insufficient domestic demand is due to the increasing income disparity between residents, which is actually more a reference to foreign scholars' related research [15,16]. For example, based on a cointegration and error correction model, Chen [17] found that the urban Gini coefficient, rural Gini coefficient, and urban and rural income ratio are all Granger reasons for the decline in the consumption rate. Zhang and Chen [18] used the Theil index to discuss the relationship between income distribution and expanding domestic demand, and they believe that the widening income gap is the fundamental factor hindering China's expansion of domestic demand and the transformation of economic growth. However, Zhu et al. [19] pointed out that this view is based solely on the measurement results and lacks sufficient theoretical support, which still needs further discussion. In recent years some empirical results have also come to the opposite conclusion: Li [20] studied the relationship between the income gap and consumption demand of urban residents in China and found that the widening income gap could not be the main cause of the inadequate domestic demand; Qiao and Kong [21] argued that the impact of the income gap on the consumption propensity is related to the level of economic development; Su and Sun [22], by depicting the "U" non-linear characteristics of Chinese residents' consumption demand with income changes, further argued that the income gap may not be the main reason for the insufficient domestic demand. From the current empirical results, this view reflects a certain degree of controversy.

Theoretically, the view of the income distribution affecting consumption is derived from Keynes [23], who proposed the rule of the "marginal propensity to decline." If a social income distribution gap widens, income will be concentrated in the hands of a small number of people, and the marginal propensity to consume will lead to a decline in consumer demand. However, this hypothesis focuses on short-term analysis and does not give sufficient attention to the long-term relationship between income distribution and consumption demand. In response to this deficiency, Modigliani proposed a life-cycle hypothesis [24], which argues that consumption depends on the permanent income not the current income. In the generalized life cycle hypothesis, he also believes that a widening income gap will lead to a lack of consumer demand through the bequest effect. Post-Keynesians believe that income distribution is a determinant of consumer demand. They have established a persuasive theoretical model [25,26] trying to reveal the relationship between income distribution and consumer demand, and the conclusion is that a widening income gap leads to insufficient demand.

In fact, these theories do not show a clear relationship between income distribution or the income gap and social aggregate demand, because they have all adopted a simplified way of using "the representative agent" to deal with the problem of aggregation, that is, the transition from the individual level to macro data. Stokes [27] confirms that the form and coefficient of the macroscopic consumption function depend not only on the form and coefficient of the microscopic function but also depend on the characteristics of the social income distribution. Campbell and Mankiw [28] then broke this homogeneity constraint and put forward the "λ hypothesis." This hypothesis holds that a class of consumers in society chooses to consume based on their permanent income, whereas the other consumers base their consumption on their current income. If you choose to spend based on your permanent income, the widening income gap will result in a reduction in consumption through bequests; if the current income is arranged to be consumed, the widening income gap will result in a reduction in consumption through a reduction in the consumption propensity.

In addition to the above two points of view, there are still aspects related to the population age structure and infrastructure that need to be considered [29,30], and it clear that there is no perfect explanation for the issue of insufficient domestic demand. Although there is little doubt that these factors could be important in explaining the insufficient domestic demand, it is less convincing that these are the main reasons because of the incompetence facing the phenomenon of the strong demand in a single market.

Therefore, China's domestic demand problem is not just a matter of level, but it is also a structural problem. There are many explanations for it, but, as we all know, the dramatic changes in the income distribution have been one of the most significant social characteristics in China [31], and the impact of income distribution is very important to consumption. Therefore, the idea of analyzing the impact of changes in income distribution on the evolution of consumption structure arose. Fitting income distribution is a traditional economic problem, especially in the field of labor economics. Recently, scholars have paid more attention to the decomposition of income distribution changes in order to dig deeper information of income changes. Using counterfactual analysis the income distribution can be decomposed into three parts: the mean change, variance change, and residual (skewness, kurtosis, and other high-order moments) change [32,33]. This study will also use this method to decompose the income distribution of Chinese residents. The counterfactual method was first proposed by Fogel [34]. He used it to measure the contribution of the railway to the economic growth of the United States in the 19th century, refuting the mainstream view that the large-scale railway investment was the main reason for the rapid growth of the US economy at that time. Today it is still widely used in the impact assessment of events or policies [35].

Although it is a new attempt to explain the demand of urban residents in China from the perspective of the income distribution change, the existing research on the consumption structure has laid a solid foundation for the work in this study. The study of consumption structure began in the 1950s. Subsequently, different models have been proposed one after another. The more famous models are the linear expenditure system (LES) proposed by Stone [36], the extended linear expenditure system (ELES) model proposed by Lluch [37], and the approximate ideal demand system (AIDS) model proposed by Deaton [38]. Among them, AIDS model is the most widely used. Based on this model, Ray [39] used household expenditure survey data to analyze the consumption structure of Indian residents, while Blanciforti and Green [40], Chesher and Rees [41] studied the food consumption situation of American and British residents respectively. Filippini [42] measured the various elasticities of Swiss household consumption. However, there is a non-linear relationship between the share of commodity expenditure and the price and expenditure in the AIDS benchmark model. Therefore, only the non-linear method can be used in the estimation, which makes the actual estimation not very convenient. Deaton [38] proposed that when the prices of various consumer goods have strong multi-collinearity, they can be approximated by linear relationship (LA-AIDS). Subsequently, the expansion of AIDS has gradually enriched, such as inverse AIDS, quadratic AIDS, two-stage linear expenditure system-approximate ideal demand system LES-AIDS, etc [43–48].

In addition, more and more scholars begin to add some other variables to traditional AIDS or LA-AIDS models, such as demographic characteristics, seasonal variables, time trend variables, structural change paths, and other external disturbances, to characterize the impact of these factors on budget share and consumption structure [40,49]. These studies make the AIDS model more perfect and convenient. Therefore, this paper also chooses AIDS model as the basic model to integrate the factors of income distribution changes.

However, numerous existing AIDS models are all based on the assumption that the expenditure is equal to the income; the expenditure is allocated among the different commodities, and then the expenditure structure is used to approximate the demand structure. Foreign economic development tends to be stable, because the residents' income is already at a high level, and the credit and social security systems are perfect. In these circumstances the residents have the courage to advance their consumption, and the expenditure structure can then better reflect the demand structure.

China's economy is operating at a rapid speed, the residents' income changes violently, and the rapid and significant change in income of hundreds of millions of people has a strong impact on consumer demand, which is rarely encountered in the development of other countries. Coupled with the lack of social security and the consumption habit of "base one's expenditures upon one's income" and other reasons, a considerable part of the residents' income is saved, so their expenditure is not equal to their income, and then the expenditure and demand structures are inconsistent. Therefore, to study China's consumption structure problem, following the existing foreign models will require some deviations.

In order to achieve the research objectives, this study will make two improvements to the AIDS model. One of these is to relax the hypothesis that the expenditure is equal to the income through the introduction of income items in the model to make it more in line with the concept of consumption of China's residents. The second improvement to the AIDS model is based on counterfactual analysis, whereby the three dynamic features of the income distribution change are introduced into the model.

3. Construction of the Model Used

In order to study the imbalance of the consumption structure from the perspective of the income distribution, we need to expand the AIDS model. The AIDS model is to achieve the established utility level by minimizing the expenditure, and the Hicks demand function is obtained. By solving the duality problem of the AIDS model, the Marshallian demand function is solved according to the utility maximization principle under the budget constraint condition so the model contains the revenue items that can reflect the characteristics of the Chinese residents' consumption. The dynamic characteristics of the changes in the income distribution of the residents are then quantified; this part mainly draws on the research of Jenkins and Van Kerm [33]. After completing the decomposition of the change in the income distribution, the income distribution characteristic is introduced into the model by means of an anti-fact process.

3.1. The Duality Problem of the AIDS Model

The AIDS model assumes that the consumer behavior satisfies the price indifferent generalized logarithmic preference hypothesis, so the expenditure function is

$$\ln(C(u,p)) = (1-u)\ln(a(p)) + u\ln(b(p)), \tag{1}$$

where $u(0 \leq u \leq 1)$ is the utility index, $u = 0$ only to maintain the basic physiological needs of the utility, and $u = 1$ for the utility to achieve its maximum. $a(p)$ and $b(p)$ denote the minimum expenditure required by the consumers to meet their basic physiological needs and obtain the maximum utility, and the form is as follows:

$$\begin{cases} \ln(a(p)) = a_0 + \sum\limits_{i=1}^{n} a_i \ln(p_i) + \frac{1}{2}\sum\limits_{i=1}^{n}\sum\limits_{j=1}^{n} r_{ij}\ln(p_i)\ln(p_j), \\ \ln(b(p)) = \ln(a(p)) + b_0 \prod\limits_{i=1}^{n} {p_i}^{b_i} \end{cases}, \tag{2}$$

According to the principle of duality, the expenditure function and indirect utility function are inverse functions, so the indirect utility function corresponding to the expenditure function is

$$v(p,m) = (\ln m - \ln a(p))/(\ln b(p) - \ln a(p)), \tag{3}$$

As obtained from the Roy equation, the Marshallian demand function for the commodity i is

$$x_i(p,m) = -[\partial v(p,m)/\partial p_i]/[\partial v(p,m)/\partial m] = (m/p_i)(a_i + \sum_{j=1}^{n} r_{ij}^{*}\ln(p_j) + b_i\ln(m/a(p))), \tag{4}$$

where $r^*_{ij} = (r_{ij} + r_{ji})/2$. Given $\mu_i = p_i x_i(p, m)/m$ represents the ratio of the expenditure to income for commodity i, we get an expanded version of the AIDS model with income m as follows:

$$\mu_i = a_i + \sum_{j=1}^{n} r^*_{ij} \ln(p_j) + b_i \ln(m/a(p)), \tag{5}$$

If we take the difference between the income and expenditure as savings, this can be seen as a special commodity that buys a certain amount of vouchers for future consumption. Let the discount rate $1/(1+r)$ be the price of the savings, where r is the real interest rate. To preserve the aggregation properties of AIDS, this is $\sum_{i=1}^{n} a_i = 1$, $\sum_{i=1}^{n} r^*_{ij} = 0$, $\sum_{i=1}^{n} b_i = 0$. Furthermore, $a(p)$ can be understood as a price index, so it can be set to $a(p) \approx \theta P$, where P is the total price index. We take it into the Equation (5), then

$$\mu_i = a^*_i + \sum_{j=1}^{n} r^*_{ij} \ln(p_j) + b_i \ln(m/P), \tag{6}$$

where $a^*_i = a_i - b_i \ln \theta$, and it also satisfies the aggregation property. Moreover, Equation (6) also satisfies the homogeneity $\sum_{j=1}^{n} r^*_{ij} = 0$ and the symmetry $r^*_{ij} = r^*_{ji}$.

3.2. Counterfactual Decomposition of Income Distribution

Before the AIDS model is dynamically expanded, we should complete the measurement of the income distribution changes. For the decomposing method of the income distribution, by using a counterfactual analysis method, Jenkins and Van Kerm [33] successfully decomposed the income distribution change into three parts, which reflect the mean, variance, and residual changes. In fact, the residual change reflects the skewness, kurtosis, and other high-order moments changes of the income distribution. Counterfactual analysis can be understood as an application of comparative static analysis, a qualitative research method in economics. The difference is that counterfactual analysis is a quantitative analysis method. It constructs a counterfactual situation in which only one factor changes but other factors remain unchanged relative to a basic fact. And it evaluates the impact of a single factor by comparing the results of counterfactual and factual situations based on specific regression models or statistical methods., so we will use the counterfactual decomposition method of Jenkins and Van Kermin in this study.

Suppose that we have and y_2 for two years of the income survey data, assuming we temporarily disregard the price factors and they follow the same distribution, $y_1 \sim F(\mu_1, {\sigma_1}^2)$ and $y_2 \sim F(\mu_2, \sigma_2^2)$, then the decomposition process can be illustrated below:

$$y_1(\mu_1, \sigma_1^2) \overset{meanchange}{\rightarrow} \xi_1 \sim F(\mu_2, \sigma_1^2) \overset{variancechange}{\rightarrow} \xi_2 \sim F(\mu_2, \sigma_2^2) \overset{residualchange}{\rightarrow} y_2(\mu_2, \sigma_2^2), \tag{7}$$

Assuming there is only a change in the mean between the two income samples, and then the underlying income ξ_1 relative to the base period y_1 can be denoted by

$$\xi_1 = y_1 + \Delta y = y_1 + (\mu_2 - \mu_1), \tag{8}$$

The variance change reflects the polarization of the income between the individuals around the mean. Based on the counterfactual analysis, we keep the mean of the counterfactual income ξ_1 and ξ_2 qual and only allow their variance changes. According to the statistical knowledge it is easy to see that

$$(\xi_1 - \mu_2)/\sigma_1 = (\xi_2 - \mu_2)/\sigma_2 \sim F(0, 1). \tag{9}$$

So we get

$$\xi_2 = \mu_2 + \sigma_2(\xi_1 - \mu_2)/\sigma_1. \tag{10}$$

The difference between ξ_2 and y_2 is the residual change.

3.3. Dynamic Expansion of AIDS Model

Equation (6) is a static model, but the change in the income distribution is a dynamic process, so the combination of the two will also be a dynamic system. Based on model (6), the expenditure share μ_i of the commodity i can be regarded as a function of the income m and the price vector p, which is $\mu_i(m, p)$; if p is kept constant, $\mu_i(m, p)$ is similar to the Engel equation of commodity i. Taking the two periods as an example, the evolution of the consumption structure caused by the income changes can be decomposed as follows:

$$\begin{cases} \mu_{i1}(y_1, p_1) \overset{price\,effect}{\rightarrow} \eta_{i1} = \mu_i(y_1, p_2) \\ \eta_{i1} = \mu_i(y_1, p_2) \overset{mean\,effect}{\rightarrow} \eta_{i2} = \mu_i(\xi_1, p_2) \overset{variance\,effect}{\rightarrow} \eta_{i3} = \mu_i(\xi_2, p_2) \overset{residual\,effect}{\rightarrow} \mu_{i2}(y_2, p_2) \end{cases}, \tag{11}$$

The above process is clearly also a counterfactual decomposition process and its first step is to eliminate the impact of the price change. The mean, variance, and residual effects of the evolution of the consumption structure caused by income distribution change are then denoted by Δ_1, Δ_2, and Δ_3, respectively. So,

$$\begin{array}{l} \Delta_1 = \eta_{i2} - \eta_{i1} = \alpha_i \ln(\xi_1/y_1) \\ \Delta_2 = \eta_{i3} - \eta_{i2} = \beta_i \ln(\xi_2/\xi_1) \\ \Delta_3 = \mu_{i2} - \eta_{i3} = \theta_i \ln(y_2/\xi_2) \end{array} \tag{12}$$

Then, the dynamic expansion model of AIDS can be obtained as follows:

$$\begin{aligned} \mu_{i2} &= \eta_{i1} + \Delta_1 + \Delta_2 + \Delta_3 \\ &= a_i^* + \sum_{j=1}^{n} r_{ij}^* \ln(p_{j2}) + b_i \ln(y_1/p_2) + \alpha_i \ln(\xi_1/y_1) + \beta_i \ln(\xi_2/\xi_1) + \theta_i \ln(y_2/\xi_2) \end{aligned} \tag{13}$$

Equation (13) is the dynamic expansion of the AIDS model, which includes the factors of the income distribution change. The dependent variable is the consumption share of each commodity in the second period, and the independent variable contains two kinds of price factors and income distribution factors: $\sum_{j=1}^{n} r_{ij}^* \ln(p_{j2})$ denotes the impact of its own price and the interactive price, and $\ln(y_1/p_2)$ represents the change in real income due to the price changes. These factors measure the effect of the price on various expenditures together, as the nominal income remains constant. Obviously, the three items $\ln(\xi_1/y_1)$, $\ln(\xi_2/\xi_1)$, and $\ln(y_2/\xi_2)$ indicate the impact of the changes in the income distribution, which is the focus of this study.

4. Data Preparation and Regression Equation Setting

4.1. Data Preparation

The focus of this study is to examine the issue of China's domestic demand, not the dynamic evolution trend of the consumption structure. As can be seen from the consumption rate curve in Figure 1 (source: [1]), the significant decline in consumption rate occurred between 2000 and 2010 is what we want to explain from the structural level. In addition, as China's economy enters a new normal, the statistical caliber of urban residents' income has also changed since 2012. After 2010, only two years of data are available. For the robustness of the results, the empirical discussion focuses on the provincial panel data from 2000 to 2010.

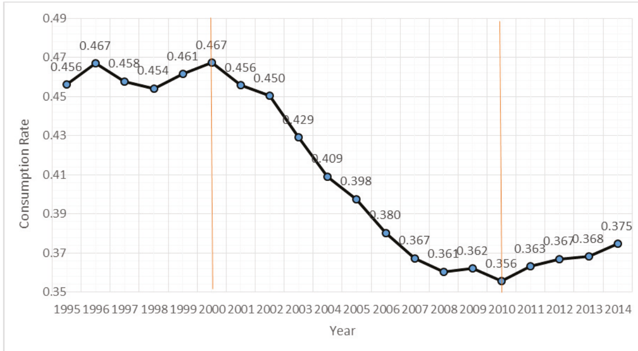

Figure 1. Consumption Rate of Chinese Urban Residents during 1995–2014.

The data used are mainly from the National Statistical Yearbook 2000-2010 data in respect of the urban residents in the provinces. The indicators used include the expenditure data for eight categories of goods, the disposable income data, the classified consumer price index, and the annual nominal interest rate data. The eight categories of goods are food, clothing, residence, household facilities, medical care, transportation and communications, entertainment and education, and other miscellaneous expenses and services. The nominal interest rate used is a 1-year time deposit rate, which is actually the average annual interest rate. Because the government only announces the corresponding interest rate of the adjustment day, if there are multiple interest rates in a given year, this study will average the different interest rates by the number of days. In addition, we still need to construct some new indicators based on the available data.

For the income indexes, which are the last three income items in model (13), the structure of the two potential income variables ξ_1 and ξ_2 are relative to the income of the previous year, so the change in the income distribution is measured between the adjacent two years. The standard deviation will be used when we calculate ξ_2; the income data of the yearbook are derived from the same household survey data, so the standard deviation is calculated by using the data of seven income levels in each year, and the proportion of the population in each group is 0.1, 0.1, 0.2, 0.2, 0.2, 0.1, and 0.1, respectively (see Table 1).

Table 1. Disposable Income of Chinese Residents by Group.

Year	Per Capita Income	Lowest	Low	Lower Middle	Middle	Upper Middle	High	Highest	Standard Deviation
2000	6280.0	2653.0	3633.5	4623.5	5897.9	7487.4	9434.2	13,311.0	1122.7
2001	6859.6	2802.8	3319.7	4946.6	6366.2	8164.2	12,662.6	15,114.9	1424.4
2002	7702.8	2408.6	3032.1	4932.0	6656.8	8869.5	15,459.5	18,995.9	1919.1
2003	8472.2	2590.2	3295.4	5377.3	7278.8	9763.4	17,471.8	21,837.3	2224.4
2004	9421.6	2862.4	3642.2	6024.1	8166.5	11,050.9	20,101.6	25,377.2	2609.4
2005	10,493.0	3134.9	4017.3	6710.6	9190.1	12,603.4	22,902.3	28,773.1	2988.4
2006	11,759.5	3568.7	4567.1	7554.2	10,269.7	14,049.2	25,410.8	31,967.3	3303.3
2007	13,785.8	4210.1	6504.6	8900.5	12,042.3	16,385.8	22,233.6	36,784.5	3406.6
2008	15,780.8	4753.6	7363.3	10,195.6	13,984.2	19,254.1	26,250.1	43,613.8	4087.8
2009	17,174.7	5253.2	8162.1	11,243.6	15,399.9	21,018.0	28,386.5	46,826.1	4366.2
2010	19,109.4	5948.1	9285.3	12,702.1	17,224.0	23,188.9	31,044.0	51,431.6	4750.0

Note: The per capita income data are not calculated and are the original data in the China Statistical Yearbook. All data were converted using 2000 as the base year.

For the price indicators we use the 2000–2010 consumer price indices for the various commodities based on 2000. We take the discount rate $1/(1+r)$ as the price of the savings, where the real interest rate r is obtained by using the annual nominal interest rate minus the total consumer price index.

In order to maintain the order of magnitude consistent with the other commodity price indices, the savings price is also converted at the 2000 base price. The total price index also needs to be reconstructed assuming that the share of savings is s, then the "total price index = $(1-s)\times$ total expenditure price index $+s\times$ savings price index."

4.2. Regression Equation Setting

With the rapid economic growth, residents' living standards have undergone great changes, so the consumer spending structure is bound to change significantly as a consequence of this. Therefore, the problem of structural mutation must be considered when we estimate the model. In order to avoid the estimated error caused by the artificial set of abrupt points, this study chooses to use Hansen's threshold method to find the abrupt points [50–52], which is completely determined by the data, so we introduce dummy variables in model (13) as Hansen did. The equation for setting a single mutation point is as follows:

$$\begin{aligned}\mu_{it} = & \sum_{j=1}^{n} r_{ij}^{*}\ln(p_{jt}) + b_i \ln(y_{t-1}/p_t) + [a_{i1}^{*} + \alpha_{i1}\ln(\xi_{1t}/y_{t-1}) + \beta_{i1}\ln(\xi_{2t}/\xi_{1t}) + \theta_{i1}\ln(y_t/\xi_{2t})]\cdot h_1(t<T) \\ & + [a_{i2}^{*} + \alpha_{i2}\ln(\xi_{1t}/y_{t-1}) + \beta_{i2}\ln(\xi_{2t}/\xi_{1t}) + \theta_{i2}\ln(y_t/\xi_{2t})]\cdot h_2(t\geq T)\end{aligned} \quad (14)$$

where T is the structural break point, $h_1(t<T)$ and $h_2(t\geq T)$ are both indicator functions. If $t<T$, then $h_1=1$, and h_2 has a similar definition. This study only adds the dummy variable to the intercept term and the income change factor; the price variable is not the focus, so we take it as the control variable. Because of the use of the panel data, the equation intercept also introduces province dummy variables to remove the impact of the individual effects, which is not reflected in the equation.

When the structural mutation is not considered, the degree of freedom of the system is 92, so in order to ensure the robustness of the estimation results, the time interval span set in this study is not less than three years. The sample point for each year is 31, which ensures that there are no less than 93 data observations per interval. Therefore, the potential mutation points considered in this study are in the 2003–2007 range. In addition, Hansen chooses the residual squared sum as the criterion of fitting and then determines the mutation point, and this study chooses the logarithmic maximum likelihood statistic in the regression result. The larger the likelihood value, the more likely that the corresponding potential mutation year is real.

From the above results (Table 2), the corresponding logarithmic likelihood is largest in 2004, and the results of the likelihood ratio test show that the original hypothesis of structural change is rejected at the significance level of 1%, so the structural mutation point T is 2004. So far, the final regression equation used in this study has been obtained.

Table 2. (a, b) Determination of the Point of Structural Change.

(a)

Mutation Point	2003	2004	2005	2006	2007
Likelihood Value	9033.876	9035.975 *	9035.189	9001.732	8980.904

(b)

Likelihood-ratio Test	Test Statistic	df	Probability	Critical value		
				1%	5%	10%
Assumption: No Structural Change	250.20	32	0.000	53.486	46.194	42.585

Note: (a) Tests of potential mutation years, (b) Nonlinear test with 2004 as the mutation year. * indicates that the value is the largest. The "df" is the degree of freedom and the likelihood-ratio test is based on the results of Table 2(a).

5. Empirical Results and Discussion

5.1. The Counter-factual Decomposition of Income Distribution

From the non-parametric kernel density estimation results of the residents' income distribution (Figure 2, source: [1]), we can see that the income level and the income gap have both changed significantly, and the domestic scholars Sun and Su [31] show that the growth in the income level is dominant. Therefore, if we do not consider the growth in income when discussing the lack of demand, it is bound to exaggerate the negative impact of the income gap and thereby add fuel to the controversy mentioned earlier.

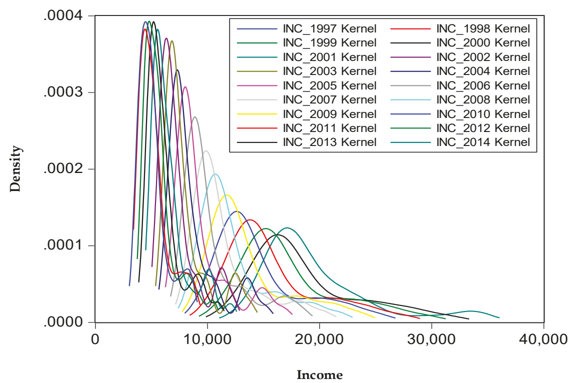

Figure 2. Non-parametric Kernel Density Estimation Results of Income Distribution.

Based on the counter-factual decomposition method of Jenkins and Van Kerm [33], the non-parametric kernel density decomposition is estimated for the per capita disposable income of the urban residents in 30 provinces. The results of the decomposition of the income distribution between the other two years are consistent, so we only take the 2005–2006 group in the middle of the study period as an example (Figure 3). The graph is in the form of a probability density curve, which is fitted according to the counter-factual income variables of each province.

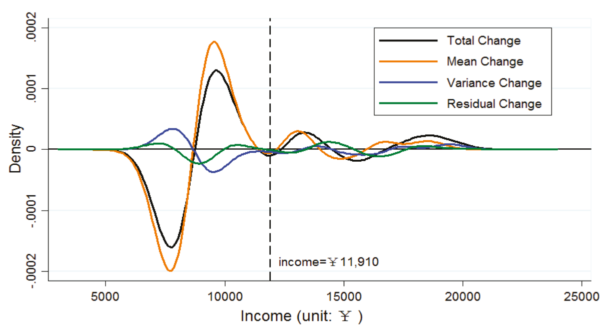

Figure 3. Decomposition of Income Distribution Changes during 2005–2006.

From the results we can see that the mean change is the dominant effect, the variance change is the second-most dominant effect, and the residual change is the smallest. Furthermore, the mean change is basically always consistent with the total change, whereas the variance and the residual change are opposite to the mean change before income 11910, then consistent with the mean change, and the residual change is slightly ahead of the variance change. It can be speculated that if the shortage of domestic demand is indeed caused by the income factors, focusing only on the income gap may not be comprehensive, because it is not the main feature of the income distribution changes. Therefore, it is necessary to rethink the problem from the whole feature of the change in the income distribution.

5.2. Model Estimation Results and Analysis

The model we used is a system, and each equation does not contain endogenous explanatory variables. If we ignore the correlation between the disturbance terms of the different equations, the ordinary least squares estimate for each equation is consistent but not the most efficient. There is likely to be a period correlation between the residents' different expenditures, so it is efficient to use the Seemingly Unrelated Regression (SUR) to estimate the entire system at the same time. In addition, since the dependent variable of each equation is the proportion of "consumption expenditure/income," the sum is 1. In order to avoid over-recognition of the model estimation, one equation must be removed. Theoretically, randomly removing any one does not affect the result, and the parameters of the removed equation can be calculated through the constraints. But the purpose of this study is mainly to examine the impact of the income distribution changes on the consumption structure, and savings exists more as a tool variable, so choosing to remove the savings equation and its estimated results will not be given. For the parameter estimates, only the coefficient estimates of $\ln(\xi_1/y_1)$, $\ln(\xi_2/\xi_1)$ and $\ln(y_2/\xi_2)$ representing the income distribution change are given.

From the estimation results (Table 3), the model is well fitted, the Root Mean Square Error (RMSE) of each equation is small, and all R-square values are greater than 0.97. Furthermore, the correlation between the perturbations of the equations have also been tested by the Breusch-Pagan test, and the last line of Table 3 shows that the p-value of the "no-period correlation" is 0, so the original hypothesis of "the disturbance term is independent" can be rejected at a significance level of 1%. Therefore, the use of SUR for the systematic estimation can improve the estimation efficiency.

Table 3. The Estimation of the Impact of Income Distribution on the Consumption Structure.

Period	Effects	(u1)	(u2)	(u3)	(u4)	(u5)	(u6)	(u7)	(u8)
2000–2004	Mean	0.219**	−0.00415	0.00676	−0.333***	0.113***	0.306***	0.278***	−0.418***
		(2.52)	(−0.80)	(0.11)	(−6.75)	(2.76)	(3.90)	(4.56)	(−11.68)
	Variance	0.266***	−0.0576	−0.0357	-0.0626*	0.108***	0.0536	0.142***	−0.138***
		(4.02)	(−1.46)	(−0.73)	(−1.66)	(3.43)	(0.89)	(3.00)	(−5.23)
	Residual	−0.0321	−0.0838***	−0.0465*	0.0166	0.0380**	0.0101	0.0135	−0.00973
		(0.90)	(−3.92)	(−1.76)	(0.83)	(2.25)	(0.31)	(0.53)	(−0.66)
2005–2010	Mean	−0.106***	−0.0274	−0.0400	−0.0142	−0.0350**	−0.0504*	−0.0100	0.0203
		(−3.28)	(−1.37)	(−1.59)	(0.74)	(−2.17)	(−1.65)	(−0.42)	(−1.55)
	Variance	−0.125**	0.0128	−0.125***	0.0318	−0.0508*	0.0308	0.0946**	0.0966***
		(−1.98)	(0.35)	(−2.67)	(0.91)	(−1.70)	(0.55)	(2.14)	(3.94)
	Residual	−0.0626*	0.0378*	−0.0522**	0.00428	−0.0111	0.0234	0.0353	0.0319**
		(−1.76)	(1.79)	(−2.00)	(0.22)	(−0.66)	(0.73)	(1.41)	(2.17)
RMSE		0.0105	0.0061	0.0075	0.0057	0.0047	0.0094	0.0071	0.0042
"R-sq."		0.9986	0.9946	0.9905	0.9858	0.9928	0.9887	0.9948	0.9795
Breusch-Pagan test of independence: chi2(28) = 174.237, Pr = 0.0000									

Note: The t statistics are in parentheses. The symbols and thresholds are * for p < 0.1, ** for p < 0.05, and *** for p < 0.01. "R-sq" represents R-squared statistics. (u1)–(u8) represent eight categories of goods: (u1) food, (u2) clothing, (u3) residence, (u4) household facilities, (u5) medical care, (u6) transportation and communications, (u7) entertainment and education, and (u8) other miscellaneous expenses and services.

For the period 2000–2004, the impact of the mean effect on clothing and residential consumption is not statistically significant. Among the consumption items that are significantly affected by the change in the mean of the income distribution, there is a positive impact on the consumption of food, medical care, transportation, entertainment, and education, and a negative impact on consumption of household equipment and miscellaneous services. We know that the demand for basic living expenses for food, clothing, and household equipment in China had been basically met by the year 2000 as a result of the rapid increase in the overall income level of the residents. According to the data in the 2001 China Statistical Yearbook, by the end of 2000 the three sets of traditional home appliances, TV sets, washing machines, and refrigerators, had reached a high level of 116.56 units, 90.52 units, and 80.13 units per 100 urban residents. Therefore, during this period the proportion of household consumption expenditure on household equipment decreased with the increase of income, thereby reflecting the "Engel Law" trend. The positive effect of the mean change on food expenditure shows that the dietary structure of Chinese residents in this period was further optimized; people not only took "eat full" as a standard, more and more chose to pursue the "eat good" policy with an improvement in their food quality, and the proportion of spending on dining outside the home also increased. The trend with clothing expenditure is just between the middle of the two types of goods. The proportion of the expenditure on clothing is not sensitive to the growth of the income level, indicating that the residents' basic needs have been met, but the pursuit of quality has not yet been reflected. During this period, residents mainly focused on the three "core consumption" categories, which are health care, transportation and communications, and entertainment and education. This consumption structure represents a transition from a basic one to a development-centric one, but the enjoyment-centric consumption represented by the "other miscellaneous expenses and services" had not yet attracted the attention of the urban residents in the short term; they chose to reduce the basic type of consumption and transfer their focus onto the development-centric consumption.

China's income distribution is obviously right-sided, with the high-income groups growing rapidly, so the variance effect and residual effect mainly represent changes in the consumption choices of the high-income earners. The variance effect for the period 2000–2004 has a significant positive effect on the consumption of food, medical care, culture, and education, whereas it has a significant inhibitory effect on household facilities and miscellaneous services and has no significant effect on other items. This indicates that the high-income group will further increase their share of expenditure on food, medical care, and cultural education. As their income grows at a relatively faster pace, more income will be used to enjoy higher quality food and health care services and to receive better quality education, which may enhance their individual heterogeneity advantages and help them to stay in the forefront in terms of income distribution. However, the expenditures on household equipment, tourism, and other miscellaneous services have also been reduced, which may have been caused by a lack of innovation in the home appliance industry and the immaturity of the tertiary industry at that time.

The residual effect reflects the choice of the consumers with the most heterogeneous advantage, whose position in the income distribution levels was relatively higher. During 2000–2004 the residual effect had no significant effect on the other items except that there was a significant negative impact on the consumption of clothing and housing and a positive effect on the consumption of health care. As they are the group with the fastest growing income, they are most concerned about medical expenses and may even sacrifice some short-term clothing and residential consumption to meet their medical expenses. The difficult problem of seeing a doctor was always the focus of the society's attention in this period.

During 2005–2010 the mean effect had a significant negative effect on food, health care, and transportation, but the impact on the other categories of consumption was not significant. Therefore, compared with 2000–2004, the positive pull impact of the mean effect on the consumption rate disappeared, which perhaps just reflects the problem of the continuing decline of China's consumption rate with the mean effect reflecting the consumption dynamics of the main body of society. Fortunately, the variance and residual effects reflect some positive effects on individual markets, such as the variance effects on the expenditure on cultural and educational activities and miscellaneous services, and the residual effects on clothing and other services, even though their negative impacts on certain markets still exist. Based on the results, first, the second round of household food consumption has been completed, so the three effects of the income distribution are negative. Second, thanks to the deepening of the health care reform since 2005, which was defined as "The Year of Hospital Management" by the government, the medical expenses proportion of income has been reduced significantly. Finally, the trend of further escalation of the consumption structure is beginning to emerge, which shows that families with faster income growth tend to increase their spending on education and services. In addition, the attitudes towards apparel consumption have changed with people beginning to focus more on the quality and brand of clothing.

Considering the importance and centrality of real estate to China's economy, the issue of residential consumption will be discussed separately here. The results of Table 3 show that the mean effect of the two periods both had no significant effect on the residential consumption. The variance effect was not significant before 2004 but began to show a significant negative effect after 2004, while the residual effect reflects the negative impact on the consumption devoted to living expenses in the two periods. It is easy to understand why the mean effect is not significant, and this is because since 1998 the implementation of housing distribution monetization replaced the previous housing in-kind distribution. China's housing prices began to rise, especially in 2000–2010, which is known as the "Golden Decade" of the real estate market. Under the continued rising expectations, the housing bubble continued to expand, and according to the statistics of the Chinese Academy of Social Sciences in 2004, in Beijing and Shanghai the overall household debt ratio, which reached 155% and 122%, respectively, was higher than the ratio for European and American families. Therefore, with the investment attributes of the house becoming stronger, the residential market has gradually moved out of line with the income levels, and the mean effect has lost its role.

It is contrary to our intuition that the residual effect in the first period and the variance and residual effects in the second period have shown a negative impact on residential consumption, because most people would think that high-income people are characterized by residual and variance changes and should have increased their living expenses. To understand the statistical content of the Chinese Bureau of Statistics in respect of the consumption on living expenses, we find that most of the statistics use costs for the items including housing and decoration materials, rent, mortgage payments, daily energy consumption, and maintenance, but the expected income from that investment that should be taken into consideration is not included. For example, renovation costs that are incurred are included in the statistics reported, and generally Chinese families that are home owners choose to decorate the house they live in, but they do not decorate it for speculative reasons. Therefore, in the context of the increasing investment demand for houses, the complementarity between the usage cost and the housing expenditure is gradually weakened, and the substitution characteristics are gradually reflected. A few high-income families characterized by residual change chose speculative living expenses in 2001–2004, while in 2005–2010 the majority of high-income groups characterized by the variance effect were also involved, thereby strengthening the negative impacts of residual and variance effects on residential consumption.

In summary, the above model estimates are statistically significant, and they are consistent with the actual situation that prevailed in China over that time. The consumption effect of the income distribution in the two periods is obviously different. The mean effect is the theme during 2001–2004, and the change of the consumption structure from a survival mode to a development mode is the mainstream. However, the mean effect during 2005–2010 is no longer significant with the overall consumption being weak. Fortunately, in the individual markets, with regard to the high-income groups, the variance and residual effects reflect their positive side, which strengthened the individual market demand, and the consumption structure also shows signs of further escalation.

5.3. Quantitative Counterfactual Estimation of the Effects

The preceding analysis is qualitative, but as is customary in studies of the consumption structure, quantitative elastic analysis is still needed. However, after introducing the income distribution variables into the AIDS model, the economic meaning of the variables that this study is concerned with becomes difficult to define when performing elasticity analysis, especially the interpretation of the variance and residual terms. Therefore, we have decided to abandon the elasticity analysis and directly use the previous counterfactual analysis framework and the model's estimation results to quantitatively measure the impact of the three factors of the income distribution on the consumption demand structure of the different commodities. We are then able to complete the interpretation of why China's household consumption rate continued to decline.

The essence of the simulation is based on the counterfactual sample constructed to predict the expenditure-income ratio for each category of goods. In the simulation process the coefficient estimates and variables in the sample other than the income factor remain unchanged. We are only assuming that the income distribution variables are changed according to the following three counterfactual cases. We still take two periods as an example, and the change in income is subject to Equation (7). Assuming that the income in the first period is y_1, which we already know, $u_{i2} = u_{i2}(\xi_1, \xi_2, y_2)$ can be determined by model (14), whose coefficients have already been estimated. If, for example, we assume no change in the income distribution, then we get the predicted value $\hat{u}_{i2}(y_1, y_1, y_1)$, but if only the mean change occurs, its predicted value is $\hat{u}_{i2}(\xi_1, \xi_1, \xi_1)$, and so on. Finally, the following results are obtained:

- Total effect: $\hat{u}_{i2}(\xi_1, \xi_2, y_2) - \hat{u}_{i2}(y_1, y_1, y_1)$
- Mean effect: $\hat{u}_{i2}(\xi_1, \xi_1, \xi_1) - \hat{u}_{i2}(y_1, y_1, y_1)$
- Variance effect: $\hat{u}_{i2}(\xi_1, \xi_2, \xi_2) - \hat{u}_{i2}(\xi_1, \xi_1, \xi_1)$
- Residual effect: $\hat{u}_{i2}(\xi_1, \xi_2, y_2) - \hat{u}_{i2}(\xi_1, \xi_2, \xi_2)$

By the above process, every two years' demand effects of the income distribution change on different commodities in each province are obtained.

The estimated results for each effect by the year group are given in Figure 4, which is obtained by averaging the provincial data. The results show that the mean effect is the largest effect in all kinds of consumption and from it the size and direction of the total effect is basically determined, but its role is to reduce the consumption rate in a comprehensive view. For home equipment the mean effect is changed from a negative effect before 2004 to a positive effect after 2004, but the positive effect is very small. As the industry has been in a very mature stage, most of the consumption is to meet the needs of family equipment updates, so there is little room for further improvement in the proportion of the expenditure in the future. The impact of the mean effect on miscellaneous consumption and service items is developing in a positive direction, and there is a potential for further improvement, but it is still in a negative stage in the figure. The mean effect on the consumption of clothing has always reflected the inhibitory effect, and the effects of the mean on the other five categories all change from positive to negative and show a downward trend.

The variance effect and the residual effect are relatively small, so in order to show the results more clearly, Table 4 gives the yearly average of the effects of the two phases. Among the three effects, the residual effect is the smallest, and has a certain individual randomness, so no further analysis is warranted. For the variance effect the expansion of the income variance had a negative effect on consumption before 2004. This was mainly because it hindered the upgrading of the consumption structure of the medical, transportation, and cultural and educational consumption, but at the same time it played a positive role in the clothing, living, and home equipment categories, especially in service consumption, which represents the main direction for the further upgrading of the consumption structure. In the second stage the promotion effect of the variance on the food, living, and medical care categories was a rare bright spot when the mean effect was almost entirely negative. On the whole, the effect of the variance was much smaller than that of the mean and did not affect the overall trend of the total effect, but the variance of the income distribution still had a positive effect on the individual markets.

Figure 4. Counterfactual Decomposition of the Income Distribution's Consumption Effects.

Table 4. Annual Average Estimate of the Income Distribution's Consumption Effects.

Period	Effects	(u1)	(u2)	(u3)	(u4)	(u5)	(u6)	(u7)	(u8)
2000–2004	Total	0.01995 (100)	−0.00378 (100)	0.00116 (100)	−0.03490 (100)	0.01070 (100)	0.03216 (100)	0.02795 (100)	−0.04304 (100)
	Mean	0.02355 (118.04)	−0.00447 (118.25)	0.00073 (62.51)	−0.03578 (102.52)	0.01213 (113.36)	0.03288 (102.25)	0.02987 (106.90)	−0.04492 (104.37)
	Variance	−0.00364 (−18.25)	0.00079 (−20.82)	0.00049 (41.96)	0.00086 (−2.46)	−0.00147 (−13.74)	−0.00073 (−2.27)	−0.00194 (−6.94)	0.00189 (−4.39)
	Residual	0.00004 (0.18)	−0.00010 (2.51)	−0.00005 (−4.56)	0.00002 (−0.05)	0.00004 (0.40)	0.00001 (0.04)	0.00002 (0.05)	−0.00001 (0.03)
2005–2010	Total	−0.01205 (100)	−0.00389 (100)	−0.00364 (100)	0.00150 (100)	−0.00396 (100)	−0.00691 (100)	−0.00239 (100)	−0.00370 (100)
	Mean	−0.01362 (113.03)	−0.00352 (90.49)	−0.00514 (141.21)	0.00182 (121.32)	−0.00450 (113.64)	−0.00648 (93.78)	−0.00129 (53.97)	−0.00261 (70.39)
	Variance	0.00115 (−9.54)	−0.00012 (3.08)	0.00115 (−31.54)	−0.00029 (−19.32)	0.00047 (−11.74)	−0.00028 (4.05)	−0.00087 (36.40)	−0.00088 (23.88)
	Residual	0.00042 (−3.46)	−0.00025 (6.43)	0.00035 (−9.56)	−0.00003 (−1.87)	0.00007 (−1.87)	−0.00016 (2.32)	−0.00023 (9.62)	−0.00021 (5.73)

Note: The numerical values in brackets indicate the percentage of contributions corresponding to each effect; the total effect is 100.

5.4. Discussion on China's Insufficient Domestic Demand

The impacts of the changes in the income distribution on the consumption structure have been adequately analyzed. On this basis, this section discusses the problem of insufficient domestic demand in China. It is easy to judge from the previous analysis that the main reason for the decline in the consumption rate may not be the expansion of the income gap, it is likely to be caused by the recession of the incentive effect on the consumption demand made by the increasing income level. In other words, the mean effect of the income distribution change has not been fully released in the markets. Therefore, we now discuss why the mean effect is weakened.

Based on the previous results, we further summarize the influence direction of the mean and variance effects on a fixed commodity when the different groups from high to low income levels pass through a fixed commodity market (Table 5). For simplicity, assume that there are only low, medium, and high income groups, the income distribution changes as shown in Figure 2, both the income mean and the variance increase, and there are the following four cases:

- Case 1: Suppose this is a new commodity, and its price is relatively high, so its market initially is only the high-income families. It is easy to judge that the increase in income levels will promote its demand growth, while the widening income gap will make high-income residents enter the market faster, which will also increase the demand, so the two effects are both positive.
- Case 2: When the main body of the population, the middle-income group, begins to pay attention to the goods, the increase in the income levels will still drive demand growth. However, the larger variance will cause the income distribution to polarize and the distribution curve to become flat, so the size of the middle income groups will be reduced, which may inhibit the growth of demand. Therefore, the mean effect is positive and the variance effect is negative at this time.
- Case 3: When the middle income group leaves the market, only the demand from the low-income families is not met. The increase in income levels will lead to more people's needs being met and cause them leave the market, but the expansion of the variance will increase the size of the low-income group and delay the decline in demand. Therefore, the mean effect is negative and the variance effect is positive.
- Case 4: When all the families have the ability to buy the goods, the goods become popular. This causes the upgraded goods to be effectively a new commodity, and at this point the increase in the mean and variance of the income will lead to a reduction in the demand for the commodity, so the two effects are both negative.

Table 5. The Influence Direction of the Mean and Variance Effects on a Fixed Commodity.

	Effects	Case 1	Case 2	Case 3	Case 4
Income Distribution Change	*Mean*	+	+	−	−
	Variance	+	−	+	−

Note: The symbol "+" indicates a positive effect, and "−" indicates a negative effect.

We use the summary in Table 5, combined with the information in Figure 4 and Table 4, to help us give the reasons below for the diminishing mean effect.

First, it can be seen from Table 4 that many of the expenditure items are in Case 3 and Case 4 in Table 5; that is, most commodities are no longer the core consumer choice of the middle and above income families, and their market demand has begun to decline. This reflects the irrationality of the supply-side structure, whereby there is an excess supply of low-end products but a shortage caused by the targeted consumption that cannot be met in a timely manner. Therefore, the mean effect is weakened and the market demand cannot be fully released.

Second, the rapid rise in house prices after 2000 may have inhibited the release of the mean effect. Campbell and Cocco [53] believed that housing prices may make some residents "save for buying a house" and thereby reduce their consumption. Figure 4 shows that the effect of the variance on the living consumption is positive and has a tendency to strengthen. Table 4 further confirms this result. At the same time the mean effect on the living consumption is changed from positive to negative, but it should be noted that this is not the corresponding case 3 in Table 5, which reflects the plight that the middle-income people face when entering the housing market. After the reform of the real estate market in 1998, the increase in the mean and variance of the income in the first stage played a catalytic role in helping high-income families to own one house, and the real estate market soon became overheated. Due to the speculative properties of housing, some high-income people changed from being consumers to becoming speculators, which led to the emergence of a real estate bubble. In this environment house prices are rising at a speed far faster than the improving speed of the average income, and the threshold of residential consumption continues to increase. Middle-income families are trapped in residential consumption, which greatly hurts their enthusiasm for consumption. They have to passively save in order to buy a house, so ultimately the mean effect is suppressed, not only in respect of residential consumption but also in respect of other consumption.

Finally, the decline in the mean effect may also be related to the macroeconomic system, such as the price system, industrial policy, financial policy, and other factors ignored by the model. These factors all need to be considered in the next step to expand domestic demand.

The results of this study can also explain the phenomenon of why some individual market demand appears hot in turns. As the mean effect is in a state of inhibition, the potential consumption capacity of the residents has not been fully released, and China's research and development ability for new products is weak, so the consumer structure often reflects "passive" upgrade characteristics when its development has reached a certain level. Once a new product meets the needs of the market, the mean effect and variance effect both will immediately promote the rapid growth of demand and lead to the phenomenon of a local hot market. Furthermore, it is then easier for enterprises to form unified short-term expectations, which will led to investment "wave phenomena" [54] and overcapacity.

6. Conclusions and Policy Implications

Inadequate domestic demand in recent years has always retarded the sustainable growth of China's economy, but the emergence of a series of local hot markets shows that it is essentially a structural problem, so it is necessary to analyze the problem of insufficient domestic demand from the perspective of the consumption demand structure. The dramatic changes in the income distribution of the residents can be said to be one of the most significant social characteristics in China since the reform, and it is also a very important factor for consumption. Therefore, this study analyzes the problem of insufficient domestic demand in China from the perspective of the effect of the income distribution on the change of the consumption structure. The main contributions of this study are summarized as follows:

First, according to the characteristics of the consumption behavior of the Chinese residents, combined with the process of anti-fact analysis of the income distribution changes, the AIDS model is extended, and the income distribution and consumption structure are placed in a model, which provides a new idea about how to study the transformation of the demand structure. The empirical results of this study are in full compliance with China's economic development practice, by which the reliability of the model is proved.

Second, the results show that the mean effect is the largest effect in all kinds of consumption, by which the size and direction of the total effect is basically determined. The variance effect is much smaller than that of the mean, but it still has some positive effects on the individual markets, such as the promotion of the demand for services, which represents the future trend of the demand structure. The residual effect is the smallest and has a certain individual randomness.

Finally, the discussion is more rational and comprehensive. In contrast to the view that the income gap leads to the insufficient domestic demand, this study argues that the income gap is not the main reason for the lack of domestic demand since 2000, but is likely to be caused by the decline of the mean effect made by the income distribution change on the market demand. There are two reasons for the failure of the mean effect: on the one hand there is the irrationality of the supply side, and on the other hand there are excessive house prices that inhibit the full release of the mean effect, which leaves most of the middle class facing a housing consumption dilemma.

Furthermore, the results of this study can also explain the phenomenon of the local hot market. As the mean effect is in a state of inhibition and China's research ability for new products is weak, the consumer structure reflects "passive" upgrade characteristics, which lead to strong consumer synchronization. Once a new product meets the needs of the market, the mean effect and variance effect will both immediately promote the rapid growth of demand and lead to the phenomenon of a local hot market.

Therefore, in the process of expanding the domestic demand, the following points should be noted. (1) In the early stages of the formation of a new consumption structure, it can be helpful to objectively treat the expansion of the income variance and control and maintain the appropriate income gap so that the positive role played by the variance effect and residual effect of the income distribution change can be fully exploited. (2) Due to the relative hysteresis of the supply structure, taking into account the imperfection of the market, entirely relying on the market mechanism to reduce the supply of surplus products is not realistic. There is still a need for the government to correct and improve the market exit mechanism in the short term in order to avoid unnecessary production [8]. Improving the innovation ability can not only make the economy realize a consumption-driven transformation, thereby fundamentally solving the problem of insufficient domestic demand, but it can also can alleviate the excess capacity caused by the "investment boom." (3) The excessive growth of house prices should be controlled to avoid its weakening impact on the mean effect. This should be accomplished by emphasizing the consumption characteristics of housing, curbing speculative demand, and improving the financial credit system to help the middle class to overcome the current consumption dilemma. (4) Advocating moderate consumption. The results of this study show that the current expansion of income variance has a positive effect on consumption, which is likely to lead to the aggravation of consumption inequality. Therefore, we should guard against irrational overconsumption, which is also not conducive to the sustainability of the economy. Experience shows that Latin American countries caught in the middle-income trap are not under-consuming, but over-consuming. So is it possible for China to have "insufficient overall consumption and excessive consumption of high-income groups" in the future? This maybe a more difficult problem related to the sustainability of economic growth. To solve this problem, we may need not only the guidance of economics, but also other fields, such as psychology, to help forming a reasonable consumption concept in Chinese society.

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Measurement of Regional Green Economy Sustainable Development Ability Based on Entropy Weight-Topsis-Coupling Coordination Degree—A Case Study in Shandong Province, China

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Abstract: Traditional development models are being slowly replaced by green economic development models. This paper views regional green economic development as a large complex system and develops a conceptual DPSIR (drivers, pressures, state, impact, response model of intervention) to construct a regional green economy development measurement index system, after which an entropy weight-TOPSIS-coupling coordination degree evaluation model is developed to quantitatively horizontally and vertically analyze regional green economy sustainable development trends and the coupled coordination status of each subsystem. The evaluation model is then employed to analyze the sustainable development of the green economy in Shandong Province from 2010 to 2016. The analysis results were found to be in line with the actual green economy development situation in Shandong Province, indicating that the measurement model had strong practicability for regional green economy development. Meanwhile, this model can demonstrate clearly how those indicators impact on the regional green economy sustainable development and fill the absence of existing studies on regional green economy sustainable development.

Keywords: green economy; sustainable development; DPSIR; entropy weight-TOPSIS-coupling coordination

1. Introduction

Green development is a necessary condition for sustainable development, which is essential for a better life in the future. Green development takes account of both development quality and development efficiency, as it is focuses on the efficient use of resources and comprehensive environmental protection. However, green development requires the harmonious and unified development of the economy, the ecology, and the society, of which green economy development is particularly important. In 1989, Pearce's "Green Economy Blueprint" first mentioned the "green economy" and claimed that the establishment of an "affordable economy" required that economic development be related to resource and environmental carrying capacities and that national economic balance should include the costs related to the polluted environment and resource waste [1]. In 2011, the UNEP pointed out that green economies needed to be low-carbon, resource-saving, and socially inclusive, should promote social equality for the benefit of mankind, and reduce environmental risks and ecological scarcities [2]. In 2012, the World Bank pointed out that green economies required environmentally friendly and highly socially inclusive economic growth so as to both protect and improve the ecological environment and make full use of natural resources to ensure the coordinated development of the society, the economy, and the environment, with economic growth being focused on sustainable development [3]. However, the traditional 'black' development concepts of unilaterally pursuing the maximization of economic benefits is deeply rooted in society, which highlights the current contradictions between economic growth, social construction, and ecological protection, such as severe haze, sandstorms, greenhouse benefits, and El Niño disasters [4]. To develop green economies further while maintaining economic development, it is necessary to first measure current economic development, explore the impacts of green economy developments, and develop methods to ensure sustainable green economy development.

To measure the current state of green economy development, this paper constructs a green economy development evaluation index system based on the drivers, pressures, state, impact, response model of intervention (DPSIR) that is combined with an entropy weight-TOPSIS-coupling coordination degree model.

In recent years, green economy development evaluation research has mainly focused on the construction of green economy development evaluation index systems and associated measurement methods. Many international authorities have developed green economy development evaluation index systems. For example, the United Nations Environment Program (UNEP) [5] established a green economy evaluation index system, The Global Green Growth Institute (GGGI) [6] built a green economy indicator evaluation system from the perspective of national development, social status, resource consumption and environmental status, , the World Commission for Environment and Development (WCED) [7] established an urban green development evaluation index system that included urban green coverage and tertiary industry, the OECD (OECD) [8] constructed a green growth indicator system to reflect sustainable economic development indicators, and the EU [9] conducted comparative selection indicator analysis. As these economic evaluation index systems mainly involved the integration of green economy development capabilities from different countries, it is not possible to specifically evaluate the regional economic development status in each region. However, research scholars have evaluated green economy development by selecting green GDP [10–12] green economy efficiency [13–15], green economy indexes [16,17], and other indicators. While these green economy evaluation index systems were able to better measure the development of green economies in certain areas, they were only able to describe green economy development levels on a macro level, and were unable to deeply analyze the impact of the economic, resource, environmental, social, and technological factor interactions on green economy development. To overcome these problems, in this paper, a DPSIR is used to construct a green economy development evaluation index system that accounts for the internal mechanisms and allows for in-depth evaluations of green economy development in a certain region or multiple regions.

Green economy evaluations need to have objective, practical, and scientific measurement methods. To date, several research methods have been developed. For example, Beijing Normal University adopted a Delphi method to determine indicator entropy so as to assess the green economy differences in different provinces and cities in China [4], Zeng, and Bi used principal component, clustering, and multiple linear regression analyses to analyze the horizontal and vertical dimensional development of the green economy in 30 provinces in China, from which it was found that the overall development was good, but the inter-regional two-level differentiation was serious [18], and Yi and Zhang used an entropy weight method and a difference coefficient to study the green economy level in 30 provinces in China in 2015, and found significant regional differences [19]. While these methods were able to comprehensively elucidate the regional green economy developments, they were unable to fully reveal the internal development restrictions. Na used an SBM model to measure provincial-level green economy efficiency in China from 1995 to 2012 and found that the regional green economy efficiency differences were large, and that the energy and carbon dioxide emissions were the key factors restricting the green economy efficiency [14], and Xiaoyun W used DEA-BCC and DEA-Malmquist models to analyze the green economy efficiency of 285 cities in China from 2004 to 2012, and found that technological progress was the main driver restricting urban green economy development efficiencies [15]. The above methods were able to identify the objective factors restricting the development of the green economy to some extent by analyzing the multi-input and output efficiencies of the complex green economy development system. However, there has been little research on green economy development trends and the degrees to which the various factors affect green economy development. Therefore, this paper adopted an entropy-TOPSIS-coupling coordination model that first vertically measures the green economy development trends and then horizontally analyzes the coordination between the various internal factors to determine the factors that are restricting green economy development.

2. Construction of the Green Economy Development Evaluation Index System

Green economy development systems are complex systems as they are influenced by economic, social, energy, environmental, and technological factors. Therefore, when constructing measurement indicators, it is necessary to ensure that each evaluation index truly reflects the state of the regional green economy development, takes account of the rationality of each evaluation index, and has sufficient applicability over a considerable period of time.

The DPSIR conceptual model, which evolved from the PSR conceptual model, was first proposed by the European Environmental Agency (EEA) in 1999 [20] to provide a basic and effective model for research into the resource environment, the social economy, and other issues. As shown in Figure 1, the DPSIR model is a complex circulatory system [21] that divided into the resource, environmental, societal, economic, and technological indicators that affect green economy development, which are then assessed into five categories; drivers (D), pressures (P), state (S), impact (I), and response (R); to take account of the indicator interactions. The model mainly emphasizes the causal relationship between human economic activities and environmental changes: human production and life drive economic development, but also bring pressure to the local ecological environment, changing the original state and nature of resources and environment; changes in the environment will also affect human life and urban development. In order to maintain the sustainable development of society, humans will take measures to respond to these changes. This model has been used to analyze regional green economy development [22], regional adaptations to climate change [23], economic development and environmental warnings [24], and economic development and carbon emissions [25], and has achieved good results.

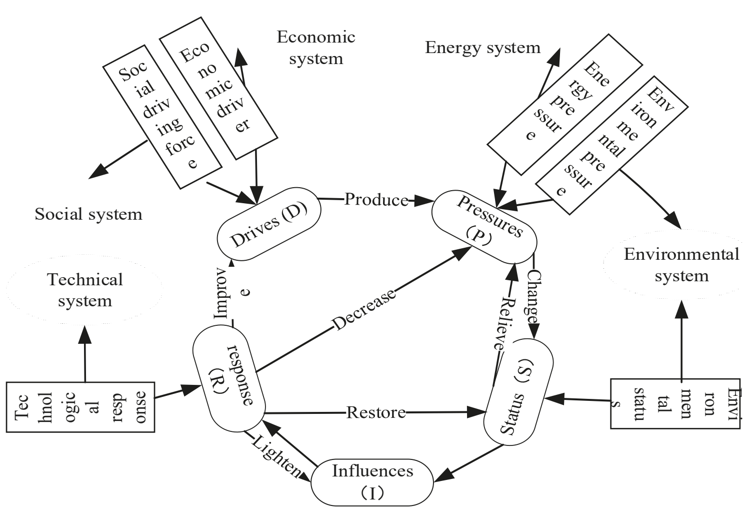

Figure 1. DPSIR green economy development evaluation system framework.

Natural resources, population, science and technology, culture, and education determine the level of regional economic development from the aspects of regional resource richness, production and consumption capacity, productivity development level, and human resource quality. The development of green economy is an inevitable choice for the sustainable development of economy, society, and ecological environment [26,27]. Green economy development is needed to improve the conflict among economic development and energy consumption, resource utilization, and environmental protection [28,29].

Shi, B. and Yang, H [16] selected 85 indicators to evaluate the urban green economy from the perspectives of economy, society, and resources. Shi, L and Xiang, X [25] from the driving force-pressure-state-impact-response selected 19 indicators including regional GDP, unit GDP energy, carbon emissions per unit of GDP, public perception of low-carbon cities, and forest coverage to evaluate urban low-carbon economy. Shen Juqin and Sun Yue [30] combined with the DPSIR model to select 28 indicators for evaluation of fixed asset investment, energy consumption, green coverage, per capita disposable income, and sewage treatment rate from the factors affecting regional green GDP development.

This paper selects 26 indicators that affect regional green economy development from five aspects: economy, society, environment, energy and technology. Because the impact is difficult to measure, to avoid uncertainty in the "I-impact" factor index in the DPSIR model criterion layer construction, a criterion layer based on the DPSR, namely the drivers-pressures-state-response, is established. Therefore, the 26 indicators are divided into economic driving force D1, social driving force D2, energy pressure P1, environmental pressure P2, environmental state S1, and science and technology response R1, total of six blocks, to measure regional green economy development.

The choice of economic driving indicators selected fixed asset investment, foreign trade volume GDP growth rate, per capita GDP, per capita disposable income of urban residents, and household consumption level from the perspectives of internal and external, national individual and income expenditure as the basis for measuring the standard economic driving force.

The choice of social driving force indicators selected the family size, per capita water use, per capita urban road area, and 10,000-person bus ownership of the household registration population from the population problem and infrastructure security level that have significant impact on social development.

Energy pressure indicators were selected by analyzing the relationship between economic development and energy consumption. The energy consumption and power consumption of the two major factors that constrain economic development are selected for measurement.

Environmental pressures reveal the industrial production that is the most vulnerable to the environment during the economic development process. Therefore, industrial wastewater discharge, industrial smoke (powder) dust emissions, industrial solid waste comprehensive utilization, SO_2 emissions per unit of GDP, and chemical oxygen demand emissions are selected as the basis for measurement.

The choice of environmental status indicators is mainly based on the perspective of green life. The pollution-free treatment rate of living garbage, the per capita park green area, the forest coverage rate, and the green area coverage of the built-up area were selected as the basis for measurement.

As an important part of promoting green development of science and technology, science, and technology response indicators should be selected from the process of investment in science and technology innovation, output, and application. Therefore, R&D expenditures accounted for the proportion of GDP, the proportion of R&D personnel with high education (master's degree or above), the number of patents granted by 10,000 people, the proportion of secondary industry to GDP, and the proportion of tertiary industry to GDP as the basis for measuring scientific and technological response. The specific indicator system is shown in Table 1.

Table 1. Evaluation index system for the green economy development based on the DPSIR.

Target Layer	Standard Layer	Factor Layer	Indicator Layer	Indicator Direction	Unit	Selection Basis
Evaluation index system for green economy development	D Drivers	D1 Economic drivers	Per capita GDP (D11)	+	CNY	Measures the state of regional economic development
			Household consumption level (D12)	+	CNY	Measures the extent to which economic development meets all aspects of human needs
			Foreign trade (D13)	+	100 million dollars	Reflects the scale of regional foreign trade
			GDP growth rate (D14)	+	%	Measures the speed of the regional economic development
			Fixed asset investment (D15)	+	100 million CNY	Reflects the comprehensive fixed investment indicators
			Disposable income of urban residents (D16)	+	CNY per person	Measures the proportion of daily income to total income
		D2 Social drivers	Household registration family size (D21)	–	Persons per household	Reflects the size of the family
			The 10,000-person bus ownership (D22)	+	Vehicles per 10,000 people	Reflects regional traffic convenience
			Per capita urban road area (D23)	+	Square meters per person	Reflects the congestion level in the area
			Per capita water consumption (D24)	–	Tonnes per person	Reflects the level of the sustainable use of water resources in regional cities
	P Pressures	P1 Energy pressures	Unit GDP energy consumption (P11)	–	Tonnes of standard coal per 10,000 CNY	Reflects the level of energy conservation in the region
			Unit GDP power consumption (P12)	–	kWh per 10,000 CNY	Reflects the level of energy conservation in the region
		P2 Environmental pressures	Industrial wastewater discharge (P21)	–	10,000 tonnes	Measures the amount of wastewater generated during industrial development
			Industrial smoke (powder) dust emissions (P22)	–	10,000 tonnes	Measures the total amount of particulate matter emitted by a company during production
			Industrial solid waste comprehensive utilization (P23)	–	%	Comprehensively reflects the extraction efficiency of industrial solid waste
			SO2 emissions per unit of GDP (P24)	–	Tons/100 million CNY	National binding emissions reduction indicator
			Chemical oxygen demand emissions (P25)	–	Tonnes	Measures water pollution
	S State	S1 Environmental state	Per capita park green area (S11)	+	Square meter	An important green space indicator
			Forest coverage rate (S12)	+	%	Reflects regional forest resources
			Pollution-free treatment rate of living garbage (S13)	+	%	Effective garbage disposal rate

Table 1. *Cont.*

Target Layer	Standard Layer	Factor Layer	Indicator Layer	Indicator Direction	Unit	Selection Basis
			Green area coverage in the built-up area (S14)	+	%	Measures regional vegetation coverage
	R Response	R1 Tech response	R&D expenditure as a proportion of GDP (R11)	+	%	Measures investment in scientific research
			Number of patents granted per 10,000 people, (R12)	+	Items per 10,000 people	Reflects scientific and technological achievements
			Proportion of R&D personnel with high education (master's degree or above) (R13)	+	%	Measures talent support for science and technology
			Proportion of tertiary industry to GDP (R14)	+	%	Measures the development of the tertiary industry sector
			Proportion of secondary industry to GDP (R15)	−	%	Measures the development of the secondary industry sector

The standard economic driving force indicators are fixed asset investments, foreign trade, GDP growth rate, per capita GDP, urban resident per capita disposable income, and household consumption level. The basic household scale and infrastructure security levels are assessed by the social driver indicators; household registration family size, per capita water consumption, per capita urban road area, and buses per 10,000-people. The current economic development stage is assessed using the energy pressure indicators, which include energy consumption and power consumption constraints, with GDP energy consumption and unit GDP power consumption being the pressure measures. The environmental pressure indicators are; industrial wastewater discharge, industrial smoke (powder) dust emissions, comprehensive industrial solid waste utilization, SO_2 emissions per unit of GDP, and chemical oxygen demand emissions. The environmental state indicators that measure the environmental green status are: the pollution-free treatment rate for living garbage, the per capita park green area, the forest coverage rate, and the green area coverage in built-up areas. As scientific and technological innovation can promote green economic development, the indicators are: R&D expenditures as a proportion of GDP, the proportion of R&D personnel with higher education (master's degree or above), the number of patents granted per 10,000 people, the proportion of secondary industry to GDP, and the proportion of tertiary industry to GDP.

3. Regional Green Economy Development System Research Model

3.1. Model Summary

The entropy-TOPSIS-coupling coordination degree model is constructed to horizontally and vertically measure the regional green economy development, the specific model for which is shown in Figure 2. First, Index weight reflects the different importance of indicators in the evaluation process, and it is a comprehensive measure of subjective and objective responses to the relative importance of indicators in decision-making (or evaluation) issues. Decancq, K. and Lugo, A. [31] summarized eight methods for setting indicator weights and highlight their strengths and weaknesses. The entropy method employs the inherent information in the evaluation indicators to discriminate the utility value of the indicators, which avoids any subjective factors, and therefore has higher credibility than subjective weighting methods such as Delphi and AHP [32,33]. TOPSIS (technique for order preference by similarity to an ideal solution), is simple to calculate and produces reasonable results as it is able to obtain the relative proximity between each evaluation object and the optimal solution by calculating the distance between each evaluation object and the optimal solution and the worst solution, after which the evaluation objects are ranked based on relative proximity [34]. The combination of these two methods (entropy weight-TOPIS) is able to more objectively and accurately reflect the evolutionary regional green economy development trends using a simple and practical calculation method.

Second, coupling is a physics concept that refers to a phenomenon whereby two or more systems or forms of motion interact [35]. The coordination degree is the degree to which the internal system factors are in harmony during the development process and reflects the system trends as it moves from disorder to order [36,37]. A coupling coordination degree is introduced to quantitatively analyze the degree of internal system coupling in regional green economy development, determine whether the coordination status of each subsystem is good or bad, clarify the role of each subsystem in the green economy development, and determine a lateral regional green economy development measurement.

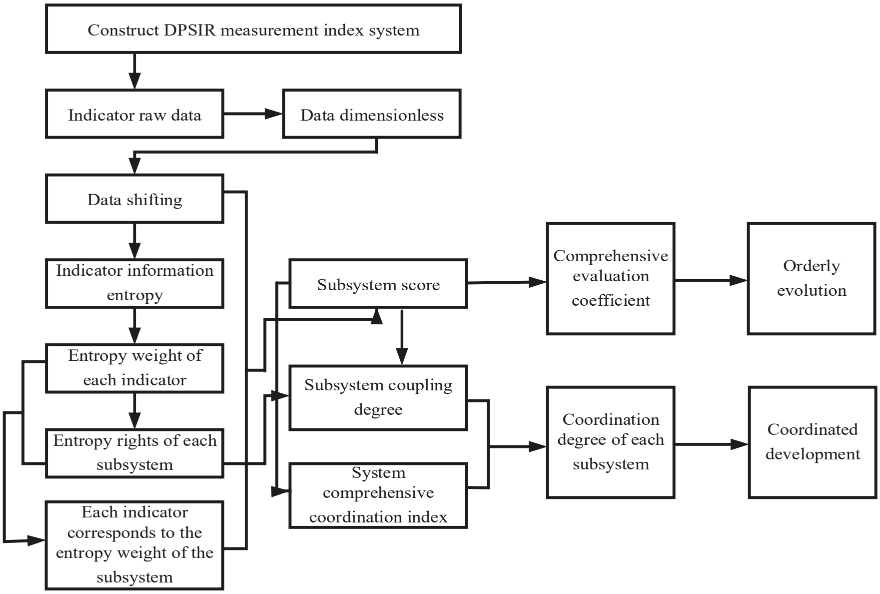

Figure 2. Research framework for the sustainable development of the green economy.

3.2. Model Solution

Step 1. Calculate the normalized measurement matrix.

With n indicators to measure the regional green economy development over m years, the initial measurement matrix can be expressed as

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix}$$

where a_{ij} represents the measurement value of the j-th measurement indicator in the i-th year.

To eliminate the different dimensions and orders of magnitude in the original variable sequences and guarantee the reliability of the measurement analysis results, a linear dimensionless processing method is applied to the initial measurement matrix. Where a_{ij} is the benefit criteria set,

$$a_{ij}{}' = \frac{a_{ij} - \min\limits_{1 \le i \le m} a_{ij}}{\max\limits_{1 \le i \le m} a_{ij} - \min\limits_{1 \le i \le m} a_{ij}} \tag{1}$$

and where a_{ij} is the cost criteria set,

$$a_{ij}{}' = \frac{\max\limits_{1 \le i \le m} a_{ij} - a_{ij}}{\max\limits_{1 \le i \le m} a_{ij} - \min\limits_{1 \le i \le m} a_{ij}} \tag{2}$$

To eliminate the impact of the index value normalized logarithmic calculations, it is necessary to coordinate the a_{ij} translation, which is expressed as

$$\mathrm{f}_{ij} = a_{ij}{}' + \theta \tag{3}$$

where θ is the translational amplitude for the relevant reference, $\theta > \min\left(a_{ij}'\right)$; when the value for θ is closer to $\min\left(a_{ij}'\right)$, the measurement result is more significant [38]; therefore, this study uses θ = 0.001; and the measured matrix $\mathrm{F} = \left[f_{ij}\right]_{m\times n}$ is then obtained.

Step 2. Determine the entropy weight for each indicator.

From basic information theory principles, information is a measure of the degree of order in a system and entropy is a measure of the degree of disorder in a system; therefore, the smaller the indicator information entropy, the greater the information provided by the indicator, the greater the effect in the comprehensive evaluation, and the higher the weight. The entropy weight rule is an objective weighting method that makes weight judgments based on the size of the data information load. Here, the objective weight for each index is determined by the degree of dispersion in the measurement index, as this reduces the influence of human subjectivity on the evaluation result and makes the evaluation results more realistic.

From the information entropy definition, the entropy value and entropy weight for the j-th measure index are calculated as

$$E_j = -\frac{1}{\ln m}\sum_{i=1}^{m}\frac{\mathrm{f}_{ij}}{f_j}\ln\frac{\mathrm{f}_{ij}}{\mathrm{f}_j}\ (j = 1,\ 2,\ \ldots,\ n) \tag{4}$$

$$w_j = \frac{1-E_j}{n-\sum_{j=1}^{n}E_j}(j = 1,\ 2,\ \ldots,\ n) \tag{5}$$

$$\text{where } f_j = \sum_{i=1}^{m} f_{ij} \tag{6}$$

Step 3. Determine the entropy weight for each subsystem.

For the multi-layered structural measurement system, based on the addition of the information entropy weight, the entropy weight W_k for each subsystem in the corresponding criterion layer is calculated using the entropy weight w_j of each index layer. The entropy weight P_j in the subsystems corresponding to each index is then obtained, after which the development scores in each subsystem Z_{ik} are calculated. It is assumed that there are s measure indicators under the k-th subsystem.

Calculate the entropy weight of each subsystem in the corresponding criterion layer W_k

$$W_k = \sum_{j=s(k-1)+1}^{s} w_j\ (k = 1,\ 2,\ 3,\ 4) \tag{7}$$

Calculate the entropy weight in the subsystem corresponding to each index P_j

$$p_j = \frac{w_j}{W_k}\ (j = 1,\ 2,\ \ldots,\ n) \tag{8}$$

Calculate the development scores for each subsystem in the i-th year Z_{ik}

$$Z_{ik} = \sum_{j=\mathrm{s}(\mathrm{k}-1)+1}^{s} f_{ij}p_j\ (k = 1,\ 2,\ 3,\ 4) \tag{9}$$

Step 4. Calculate the comprehensive evaluation coefficient C_j for the sustainable development of the green economy system based on TOPSIS.

A larger $\boldsymbol{C_j}$ value indicates that the green economy is more sustainable; therefore, $\boldsymbol{C_j}$ indicates the overall development of the regional green economy at the macro level. The specific steps are

(1) Determine the positive ideal solution Z_{ik}^{+} and the negative ideal solution Z_{ik} for each subsystem

$$\mathrm{Z}_{ik}^{+} = \{\max \mathrm{Z}_{ik} | i = 1, 2, 3, \ldots, m\} = \left\{\mathrm{Z}_{i1}^{+}, \mathrm{Z}_{i2}^{+}, \mathrm{Z}_{i3}^{+}, \mathrm{Z}_{i4}^{+}\right\} \tag{10}$$

$$Z_{ik} = \{\min Z_{ik} | i = 1, 2, 3, \ldots, m\} = \left\{Z_{i1}^{-}, Z_{i2}^{-}, Z_{i3}^{-}, Z_{i4}^{-}\right\} \tag{11}$$

(2) The distance from the *i*-th year weighted value to the positive Z_{ik}^{+} and the negative ideal solution Z_{ik} can be calculated as

$$\boldsymbol{D_i^{+}} = \sqrt{\sum_{k=1}^{4} (\boldsymbol{Z_{ik}} - \boldsymbol{Z_{ik}^{+}})^2} \tag{12}$$

$$\boldsymbol{D_i^{-}} = \sqrt{\sum_{k=1}^{4} (\boldsymbol{Z_{ik}} - \boldsymbol{Z_{ik}})^2} \tag{13}$$

(3) Calculate the relative closeness to the ideal solution and rank the performance order. The comprehensive evaluation coefficient C_i for the sustainable development of the regional green economy development system in the *i*-th year is expressed as

$$\boldsymbol{C_i} = \frac{\boldsymbol{D_i^{-}}}{\boldsymbol{D_i^{+}} + \boldsymbol{D_i^{-}}}, \ (0 \le C_i \le 1) \tag{14}$$

Step 5. Calculate the coupling coordination degree in the regional green economy.

Calculate the coupling coordination degree $\boldsymbol{K_i}$ of the regional sustainable green economy in the *i*-th year to account for the coupling degree and the coordination degree correlation characteristics, which can then be used to assess the intensity and orderly development of the annual coupling between the internal subsystems in the regional sustainable green economy. The specific steps are as follows:

(1) $\boldsymbol{M_i}$ is the sustainable green economy multi-factor coupling degree in the *i*-th year; the larger the value, the better the state of the sustainable regional green economy, the calculation formula for which is

$$\boldsymbol{M_i} = \left| \prod_{k=1}^{k} \boldsymbol{Z_{ik}} / \left(\frac{\sum_{k=1}^{k} \boldsymbol{Z_{ik}}}{k} \right)^{k} \right|^{\frac{1}{k}} \tag{15}$$

where k is the number of coupled subsystems needed to calculate the sustainable green economy development; that is, $2 \le k \le 4$, $k \in \mathrm{N}^{+}$.

(2) $\boldsymbol{Q_i}$ is the sustainable green economy comprehensive coordination index in the *i*-th year, which reflects the orderly and/or disorderly development; the more orderly the system, the better the development of the sustainable green economy; the calculation formula for which is

$$\boldsymbol{Q_i} = \sum_{k=1}^{4} Z_{ik} \times W_k \tag{16}$$

(3) The coupling degree and comprehensive coordination index are combined to determine the coupling coordination degree, which is expressed as

$$\boldsymbol{K_i} = \left| \sqrt{\boldsymbol{M_i} \times \boldsymbol{Q_i}} \right| \tag{17}$$

The larger the $\boldsymbol{K_i}$, the more cooperative the subsystems in that year, and the higher the coordination. The coordination degree is divided into 8 levels [39], as shown in Table 2.

Table 2. Coordination levels.

K_i	**0~0.09**	**0.10~0.29**	**0.30~0.39**	**0.40~0.49**
Levels	High imbalance	Moderate imbalance	Slight imbalance	Approaching imbalance
K_i	**0.50~0.59**	**0.60~0.69**	**0.70~0.89**	**0.90~1**
Levels	Reluctant coordination	Primary coordination	Intermediate coordination	High coordination

4. Case Study

4.1. Data Sources

Shandong Province has the third largest provincial economy in China, the third highest provincial GDP at 1/11 of total Chinese GDP, and is the second most populous province in China. Shandong Province is therefore, one the most economically developed and economically strong provinces, and is one of the fastest growing. While the overall economic development in Shandong Province is rising, there are still deficiencies in its green economy development. Therefore, this paper analyzes the green economy development in Shandong Province to demonstrate the validity of the proposed methods and provide guidance for future evaluations.

The index data for this study were taken from the National Statistical Yearbooks (2011–2017) [40] and the Shandong Statistical Yearbooks (2011–2017) [41], with some original data being converted using the relevant calculation formulas.

4.2. Results Analysis

As previously described, the sustainable green economy system was both vertically and horizontally analyzed. First, the overall development trends of the green economy development system were vertically analyzed, after which the coordination between the various internal green economy development subsystems were laterally measured and the restricting development factors explored.

Using Formulas (1)–(8), the entropy and entropy weights for the regional green economy development indicators in Shandong Province were calculated, the results for which are shown in Table 3.

Table 3. Entropy and entropy weights for the regional green economic development system indicators in Shandong Province.

Target Layer	Standard Layer		Indicator Layer			
	Code	W_k	Code	E_j	w_j	P_j
Sustainable Green economic development system	D	0.3666	D11	0.8716	0.0333	0.0908
			D12	0.8489	0.0392	0.1069
			D13	0.9038	0.0249	0.0680
			D15	0.8090	0.0495	0.1351
			D15	0.8321	0.0435	0.1188
			D16	0.8707	0.0335	0.0915
			D21	0.8228	0.0340	0.0929
			D22	0.7128	0.0274	0.0748
			D23	0.8530	0.0261	0.0712
			D24	0.8088	0.0550	0.1501
	P	0.2216	P11	0.8769	0.0339	0.1531
			P12	0.8539	0.0389	0.1758
			P21	0.8085	0.0277	0.1252
			P22	0.8486	0.0301	0.1360
			P23	0.8265	0.0215	0.0969
			P24	0.8687	0.0309	0.1395
			P25	0.8943	0.0385	0.1736
	I	0.2081	I11	0.8994	0.0459	0.2208
			I12	0.7878	0.0745	0.3579
			I13	0.8692	0.0381	0.1831
			I14	0.8499	0.0496	0.2382
	R	0.2037	R11	0.8930	0.0319	0.1568
			R12	0.8839	0.0379	0.1860
			R13	0.9172	0.0497	0.2438
			R14	0.8808	0.0393	0.1927
			R15	0.8517	0.0450	0.2208

As can be seen from the calculation results, the economic and social drivers in each subsystem accounted for a large proportion of the green economy development, followed by energy and environmental pressure, with the environmental state and technological response accounting for a relatively small proportion.

4.2.1. Comprehensive Evaluation Results from the Vertical Analysis

Based on the entropy weights for each layer, the green economy development level scores in Shandong Province were calculated using Formulas (9) and (10), the results for which are shown in Table 4.

Table 4. Development level scores in each subsystem of Shandong Province's sustainable green economy development system from 2010 to 2016.

Year	D	P	S	R
2010	0.3967	0.6920	0.0001	0.2209
2011	0.4290	0.7806	0.0307	0.3176
2012	0.4983	0.6315	0.3067	0.4181
2013	0.5064	0.5394	0.8348	0.4646
2014	0.5249	0.5446	0.9137	0.6052
2015	0.5467	0.5877	0.8498	0.7451
2016	0.6111	0.1883	0.9085	0.7792

Equations (11)–(15) were then applied to calculate the distance between the green economy subsystems and the ideal values from 2010–2016 and determine the closeness coefficients, the results for which are shown in Table 5.

Table 5. $\boldsymbol{D_i^+}$, $\boldsymbol{D_i^-}$ and C_i. for the development of the green economy in Shandong Province from 2010 to 2016.

Year	D_i^+	D_i^-	C_i	RANK
2010	1.0955	0.5037	0.3149	7
2011	1.0129	0.6018	0.3727	6
2012	0.7306	0.5828	0.4437	5
2013	0.4175	0.9442	0.6934	3
2014	0.3057	1.0610	0.7763	2
2015	0.2158	1.0857	0.8342	1
2016	0.5923	1.0876	0.6474	4

For further analysis, the green economy development trends were transformed from the tables into graphs, as shown in Figures 3 and 4.

As can be seen from Figures 3 and 4, the sustainability of the green economy in Shandong Province from 2010–2016 was generally rising and had good momentum. $\boldsymbol{D_i^+}$ decreased from 1.10 to 0.59, $\boldsymbol{D_i^-}$. increased from 0.50 to 1.09, and the comprehensive closeness $\boldsymbol{C_i}$ gradually increased from 0.31 to 0.83, indicating that the sustainable green economy was gradually developing towards an ideal state. The sustainable green economy system development comprehensive score from 2010 to 2015 increased from 0.34 to 0.66, indicating that Shandong's economy was continuing to develop at high speed. Although the comprehensive score in 2016 slightly decreased, it was still in a rapid development period. The progress made in recent years by Shandong Province was mainly due to the active implementation of the green economy development concept. Since 2010, the drivers and pressures and the state and response systems have been rapidly rising, the driving system has been slowly changing, and the state subsystem had the fastest rising speed, all of which was mainly due to the continuous economic and social development; however, the development speed was more moderate. Environmental protection has been gradually receiving attention, with environmental protection investment having increased substantially, which has led to a continuous improvement in the environment. At the same time, science and technology has strengthened to support economic development. However, the continuing economic growth has resulted in increased energy and environmental pressure, with the pressure on the green economy development being at a relatively high level from 2010–2015. The limited energy sources have restricted green economy development and has also caused harm to the environment.

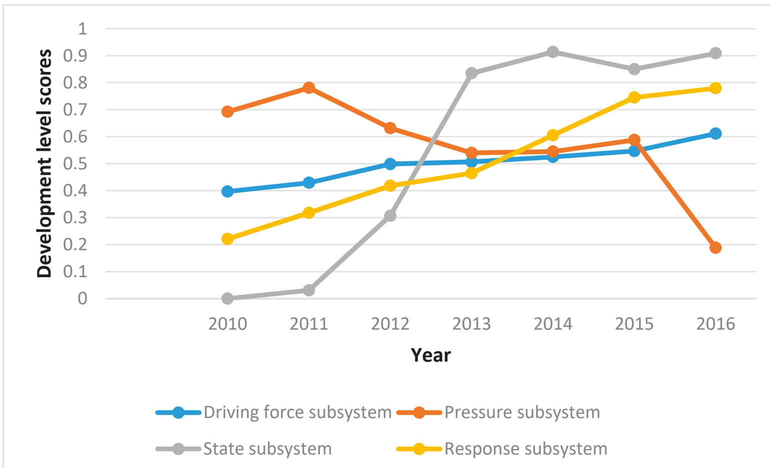

Figure 3. Development level scores for each subsystem in Shandong Province's sustainable green economy.

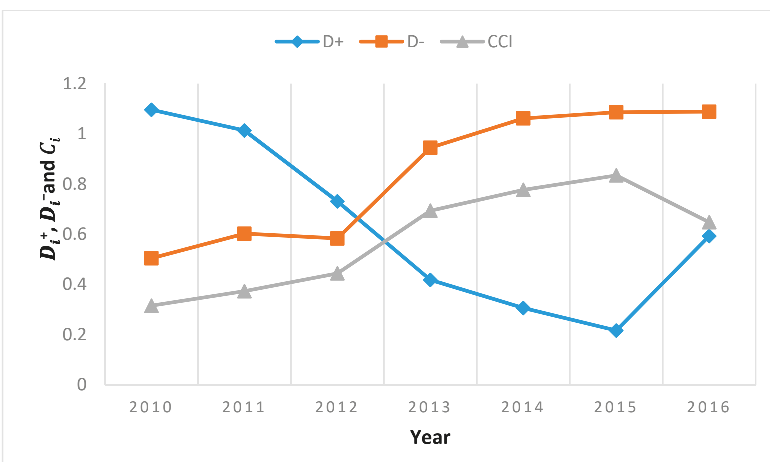

Figure 4. D_i^+, D_i^-, and C_i for the green economy system in Shandong Province from 2010 to 2016.

In short, Shandong Province faces challenges and it is necessary to continuously coordinate the relationship between green economy development and the economic, social, energy, environmental, and technological subsystems.

4.2.2. Coordinated Development Results from the Horizontal Analysis

Using Equations (16)–(18), the coupling coordination degrees between the two subsystems and the four subsystems in Shandong Province were calculated from 2010 to 2016, the results for which are shown in Table 6.

Table 6. Coupling coordination degrees between the two subsystems and the four subsystems in Shandong Province from 2010 to 2016.

Year	D-P	Coordination Level	P-S	Coordination Level	R-D	Coordination Level
2010	0.5362	Reluctant coordination	0.0607	High imbalance	0.4273	Approaching imbalance
2011	0.5621	Reluctant coordination	0.2617	Moderate imbalance	0.4685	Approaching imbalance
2012	0.5660	Reluctant coordination	0.4372	Approaching imbalance	0.5165	Reluctant coordination
2013	0.5523	Reluctant coordination	0.5352	Reluctant coordination	0.5292	Reluctant coordination
2014	0.5595	Reluctant coordination	0.5483	Reluctant coordination	0.5612	Reluctant coordination
2015	0.5748	Reluctant coordination	0.5495	Reluctant coordination	0.5900	Reluctant coordination
2016	0.4749	Approaching imbalance	0.4172	Approaching imbalance	0.6164	Primary coordination
Year	**R-P**	**Coordination Level**	**R-S**	**Coordination Level**	**D-P-S-R**	**Coordination Level**
2010	0.4122	Approaching imbalance e	0.0438	High imbalance	0.2283	Moderate imbalance
2011	0.4642	Approaching imbalance	0.2008	Moderate imbalance	0.4963	Approaching imbalance
2012	0.4694	Approaching imbalance	0.3837	Slight imbalance	0.6752	Primary coordination
2013	0.4621	Approaching imbalance	0.5072	Reluctant coordination	0.7471	Intermediate coordination
2014	0.4935	Approaching imbalance	0.5540	Reluctant coordination	0.7813	Intermediate coordination
2015	0.5292	Reluctant coordination	0.5727	Reluctant coordination	0.8056	Intermediate coordination
2016	0.3984	Reluctant coordination	0.5889	Reluctant coordination	0.7261	Intermediate coordination

For further analysis, the green economy development trends were transformed into a graph, as shown in Figure 5:

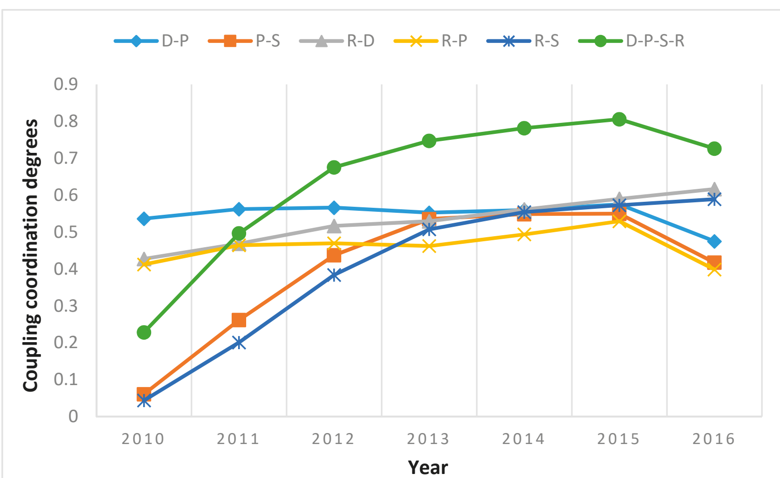

Figure 5. Coordination degrees between the subsystems in Shandong Province.

As can be seen from Figure 5, the coordination between the internal sustainable developmental subsystems in Shandong Province were steadily developing from 2010 to 2016, with the coupling coordination index rising from a moderate imbalance of 0.23 to an intermediate coordination of 0.81. The overall system coordination degree was generally higher than the coordination degree between the two subsystems. These results clearly demonstrated that the coordinated development of the complex sustainable green economy is due to the interactions of the various internal subsystems.

The coupling-coordination degree index for the response-state subsystems changed the most rapidly, with the coupling coordination degree index increasing from a high imbalance of 0.04

to reluctant coordination at 0.59, which also clearly indicated that the response-state subsystem coordination had a significant impact on green economy development. This was mainly because the scientific and technological support was generating more environmental compensation mechanisms, which were slowly encouraging scientific and technological innovation.

The coupling-coordination degree index of the pressure-state subsystems changed in an inverted U shape. From 2014–2015, the subsystem coupling coordination index attained the maximum at 0.55, which was the reluctant coordination level, which put pressure on the energy and environmental subsystems. Therefore, to promote continual positive change in the environment, continuous coordination between the energy and environmental subsystems is needed.

The coupling-coordination degree index for the response-pressure subsystem fluctuated between 0.4 and 0.5, and was therefore approaching coordination. This was because the scientific and technological responses were beginning to alleviate the energy and environmental pressures; however, there is significant room for improvement as the scientific and technological progress needs to be transformed into a driving economic development force to ease the development pressure.

The coupling-coordination degree indexes of the drivers-pressures and response-state subsystem remained at a reconciliation level. Therefore, it is necessary to continuously increase the drivers to promote steady green economy progress and ensure the application of the scientific and technological innovations

In short, Shandong Province needs to pay attention to coordinating the relationship between the science and technology response and the economy, society, energy, and the environment by increasing investment in science and technology innovation, and ensuring the innovations are transformed into economic development drivers. To fully develop the green economy in Shandong Province, its economic dependence on resources needs to be reduced, environmental pollution controls further strengthened, and a resource-conserving and environmentally-friendly society more fully promoted.

5. Conclusions

This paper constructed a sustainable regional green economy development index system from five aspects; economic, social, technological, resources, and environmental; using DPSIR and entropy-TOPSIS-coupling coordination to horizontally and vertically quantitatively analyze the sustainable green economy development. The model was verified by the actual situation of green economy development in Shandong Province from 2010 to 2016, which confirmed the feasibility of the method. The analysis in this study came to the following conclusions:

(1) The DPSIR was used to transform the internal development of each subsystem into a driver, a pressure, a state, or a response. Compared to traditional economic evaluations that tend to only reveal the surface conditions, the DPSIR was shown to more fully reveal the impact of the various factors on economic development and comprehensively analyze the interrelated relationships; therefore, based on the DPSIR theory, this paper established a green economic development evaluation index system, which provides a good theoretical framework for the global green economy development evaluation.

(2) The entropy weight-TOPSIS model established in this paper has important application value for the longitudinal analysis of green economy development. The analysis of the comprehensive green economy development scores each year was shown to determine the distance between the current development status and the ideal status in each year, thus allowing for a clarification of the green economy development trends; therefore, this method was also shown to have a good reference value for the multi-dimensional comprehensive analyses of regional green economic development systems.

(3) Coupling coordination theory was used to analyze the coordinated development of the various subsystems and identify the constraints on sustainable green economy development from economic, social, technological, resource, and environmental perspectives; therefore, as this method provides a valuable reference for the development of the green economy, targeted future development planning recommendations could be proposed based on the actual regional situation.

6. Suggested Countermeasures

The problems existing in Shandong Province during the development of green economy are universal, and the level of green economy development tends to rise as a whole, but the coordination between subsystems is still at a low level, economic growth and excessive resource consumption and weak technological support. coexist. In order to accelerate the transformation of the green economy, active measures still need to be taken. Possible measures include:

(1) Focus on developing its own advantageous industries. A green economy requires the coordinated development of the economy, the society, energy, the environment, and science and technology. As the economy acts as material support for the development process, it should be fully attended to; therefore, choosing industrial developments that suit green economy development can assist in growing the economy and reducing the dependence on environmentally polluting resources.

(2) Improve development efficiency and reduce total energy consumption. The key to successful green economy development is to increase investment in innovation and then apply these innovations to development to improve overall efficiency. Therefore, more focus and more investment need to be put on emerging industries such as green energy and environmental protection, and priority given to the energy conservation and environmental protection project development to ensure stable green economy growth, which means that the bottleneck between economic development, energy, and the environment must be broken.

(3) Focus on the development of green markets. By continuously focusing on the development of a green market, the enthusiasm in micro-subjects can be fully mobilized; however, the sustainable development of a green market requires dedicated policy guidance and constraints at the government level to encourage the development of the green economy.

However, regardless of our positive results, there were still several limitations in this study. The regional green economy development indicator system is a multi-level, multi-directional, multi-structured system. Due to indicator data measurability, this paper only considered economic, social, environmental, and other measurable indicators, and ignored the other factors that affect sustainable development, such as institutional factors and policy factors. Therefore, further research is needed to develop a more robust regional evaluation system.

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sustainability

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Review

More or Less Sustainable? Assessment from a Policy Perspective

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Abstract: Sustainability of tourism destinations has become the main focus in planning and managing tourism development. Despite existing legislation and an institutional framework to safeguard balanced tourism growth, many destinations fail to properly address it. So far, studies are limited in exploring sustainable tourism impacts from a policy perspective. This study follows previous ones in using the triple bottom line sustainability approach to define tourism impacts. It argues, in particular, for a nexus between understanding of policy perception and sustainability, and it applies this to tourist destinations in Serbia to determine whether they are operating sustainably. For this purpose, the data were collected using a combination of multiple methods, involving interviews with policymakers and content analysis of strategic documents. This study further suggests a model that assesses the extent of the sustainability of tourist destinations. The results illustrate the importance of understanding policy perceptions in shaping and facilitating sustainability and informing policy enablers on how to improve and reform current tourism development. The model can be adopted and applied to any tourist destination facing an inevitable need to re-shape their tourism development plans and policies, while the implications address the need to build a participative policy approach to sustainable tourism development.

Keywords: sustainability; perception; policy; tourism development; challenges; reforms

1. Introduction

The concept of sustainable development emerged from environmental concerns within the activities of the United Nations, reflected in the World Charter for Nature [1] and Agenda 21 [2]. It was further reoriented towards tackling socio-economic issues and reflected in a "triple pillar" context within the World Summit on Sustainable Development in Johannesburg in 2002 [3] and Rio +20 "The Future We Want" [4]. Consistent with [5–7], this concept is understood as an organizing principle for meeting human development goals while sustaining the potential of natural systems to supply the natural resources upon which society and the economy depend while aiming at achieving social, environmental, and economic progress [8,9]. Thus, sustainable development as a concept incorporates social, ecological, and economic aspects, outlining the necessity of their optimization to meet 17 sustainable development goals with 169 targets of the United Nations' Agenda 2030 [10]. However, achieving all this has been often hampered by some trade-offs and different interpretations in favor of economic growth, at the expense of social well-being and ecological viability [11].

Tourism sustainability has been long debated, and many studies from various approaches open a variety of interpretations so far. Regardless of the level of inter-dependency (destination sustainability, tourism sustainability, and sustainability of the local community), understanding the principles of sustainability are fundamental for sustainable tourism development [12–14]. The concept generally rests on the three theoretical pillars, representing socio-cultural, environmental, and economic tourism impacts. As such, the concept has been integrated into tourism strategies starting from a local to a global level. Taking into consideration various impacts tourism has on destinations, understanding stakeholders' perception is essential in minimizing potential negative effects and maximizing benefits, so an understanding of sustainability from different perspectives by those who live in the destination or use and manage resources means meeting the needs and requirements of all stakeholders (local communities, tourists, operators, and regulators). It is tourism that unifies all, boosting destinations to a higher quality in the short and long term, but, in order for sustainable tourism to be achievable, all tourism segments must work towards becoming sustainable, even if it looks like an incalculable goal and unattainable objective [15,16]. Many scholars argue about different aspects of perceptions of the sustainability of tourism, yet studies are very limited in putting the focus on policy enablers' perception [17–22]. This study follows previous findings in using the established three mainstream pillars of sustainability (socio-cultural, environmental, and economic) to define tourism impacts. It adds to the literature gap by assessing the level of tourist destinations' sustainability from a policy perspective. The policymakers represent the regulators: those who contribute to managing and controlling tourism development at the destination level (such as governmental bodies, contributors to management strategies, tourist organizations, etc.). Additionally, this study suggests a modeling framework for strategic tourism development reforms. The proposed model posts directions for the systematic organization of policymakers to infer conclusions regarding the current state of well-being of tourist destinations. It is important to assess this due to the manner of progress and to direct and monitor policies towards sustainable development.

Serbia was chosen for a case study as it seeks to develop tourism despite limitations in many aspects (lack of finances, low GDP, small investments in tourism, etc.). So far, studies have been undertaken on tourism stakeholders in Serbia [22,23], but, to our knowledge, this approach is still missing from the literature. The paper sets out the theoretical context concerning sustainability. This is followed by a brief overview of related facts and figures about the study area. The next section presents the conceptual model and methodology, followed by empirical results. Findings are discussed, followed by the concluding part of the paper.

2. Literature Review

Sustainable tourism has evolved from the original sustainable development concept, being able to "process the need of the present without compromising the ability of future generations to meet their own needs" [24] (p. 8). Since then, vast debates about the definition have ensued, resulting in the incorporation of sustainable development in the context of tourism needs, resulting in the definition of sustainable tourism. In general, this concept has become very popular and ever since continued to raise dilemmas about its validity and operationalization.

Over the years, as it gained in popularity, researchers extensively debated sustainable tourism issues [25]. Various aspects of sustainability were discussed, each from a different angle of scientific approach [26], yet many aspects of sustainable tourism are still overlooked in the literature, in terms of achieving a systematic perspective and an interdisciplinary approach, like the role of tourism demand, the fixed entity of tourism resources, the imperative of intra-generational equity, keeping the culture intact and usefully measured sustainability, and there has been some skepticism about tourism forms of sustainable development [27]. Some exceptions have been noted by [28,29], when arguing the case for one-site measurement used as an impact control measure and thus explaining the role of tourism demand from a sustainability perspective. An exceptionally strong focus on preservation and conservation of resources is argued for by addressing different aspects of the sustainability of tourism resources, like macro and micro sustainability approaches [30], "strong" and "weak" sustainability [31], the minimum resource condition to maintain constant stock [32], etc. Issues of inter-generational equity in favor of intra-generational equity as an essential prerequisite of sustainable tourism are highlighted by [33,34].

Furthermore, many scholars have debated the issue of measuring sustainability by trying to identify sustainable levels of tourism development and how these can be measured. Different methodologies with a comprehensive set of indicators are proposed, and the debate is still ongoing [15,16,35–38], yet there is no consensus on a universal list of indicators capable of revealing the sustainability level of various destinations.

Furthermore, stakeholder theory has been extensively explored, allowing the understanding of perceptions of different supporters of tourism development at the destination level [39–43]. Recent debates tried explaining tourism sustainability from residents' perspectives [44–53]. The decision-making process, planning, and management of tourism sustainability have also been addressed [54–58]. Furthermore, broad-based participation of all stakeholders in the process of developing sustainability indicators is also strongly recommended [17,59–62].

3. Study Area: Serbia

Tourism in Serbia is recognized as one of the priority areas for development and an important task on its path towards European Union (EU) integration (Table 1).

Table 1. Summarized tourism facts for Serbia.

Tourist Arrivals and Overnight Stays (2019)	3,689,700 tourist arrivals (49.96% domestic and 50.04% foreign) 10,073,200 overnight stays (60.2% domestic and 38.8% foreign) Capital cities (Belgrade and Novi Sad) 38.21% of tourist arrivals; Spa resorts 18.16%; Mountain resorts 17.3%; Other tourist resorts 21.66%; Other resorts 4.22%.
Tourist Destinations (2019)	Tourist resorts I category: Belgrade, Novi Sad, Niš, Vrnjačka banja, Zlatibor, Subotica, Kopaonik Tourist resorts II category: Kragujevac, Arandjelovac, Vršac, Kruševac, Sremski Karlovci Tourist resorts III category: Sombor, Kanjiža, Ada, Pirot, Krupanj Tourist resort IV category: Kučevo
Hospitality Sector—Accommodation (2019)	48,190 rooms with 114,771 beds 37% in hotel establishments (368 hotels with 18,184 rooms and 29,211 beds) 23.5% in spa resorts 17.7% in mountain resorts 22.6% in other tourist resorts 9.3% in other resorts
Hospitality Sector Turnover (2018)	Approx. 453,543,932.2 EUR (79.7% food and beverage, 18.1% accommodation, 2.2% other services)

Source: [63].

At the national level, tourism development is under the jurisdiction of the Ministry of Trade, Tourism, and Telecommunications, responsible for legal regulative measures, strategic planning and control. The main role in the marketing and promotion of tourist destinations at the national level is played by the National Tourist Organization. There are several regional tourist organizations, development agencies and tourist clusters having a direct role in tourism development and marketing. At the local level, such activities are under the control of municipal authorities and local tourist organizations. Overall, in the tourism planning and development process, a top-bottom approach is applied. This particularly concerns the issues related to infrastructure and capital investments. Table 2 presents a summarized framework of the institutional structure of tourism policymakers in Serbia.

Table 2. The institutional structure of tourism policymakers in Serbia.

Type of Institution/Organization	Profile of the Institution/Organization
Ministry of Trade, Tourism, and Telecommunications	Sector of Tourism; Sector of Tourism Inspection
Development Agencies	National Agency for Regional Development (since 2009) Regional Agencies: 17 (RARIS-East Serbia, RDA Rasina District, RDA Pčinja district, RDA Šumadija and Pomoravlje, RDA Belgrade, RDA Braničevo-Podunavlje, RDA Južni Banat, RDA PANONREG, RDA Bačka, RDA Srem, RDA Banat, RDA Zlatibor, RDA JUG, RDA Podrinje-Podgorina-Rađevina, RDA Sandžak-SEDA, Center for the development of Jablanica and Pčinja District)
Tourist Organizations	National Tourist Organization of Serbia Regional tourist organizations: 3 (Tourist Organization of Vojvodina, Tourist Organization of West Serbia, Regional Tourist Organization of Sandžak) Local Tourist Organizations on Municipal Level: 132
Tourist Clusters	Danube tourist cluster Istar 21 Cluster association for the development of business, MICE and event tourism Cluster of health, wellness and spa tourism Tourist Cluster SremCluster Sombor Salashs Tourist Cluster "The Hart of Sumadija" Tourist Cluster of Southeastern Serbia "Stara Planina"
Associations	YUTA—National Association of Tourist Agencies (327 tourist agencies) of total approx. 500. HORES—business association of the hotel and restaurant industry of Serbia (about 200 hotels and restaurants) TGA—Tourist Guides Association of Serbia (170 licensed tourist guides)

General sustainability frameworks are set within The National Strategy on Sustainable Development [64] and the Strategy of Tourism Development 2016–2025 [65], while different issues, measures, and goals are being emphasized in various strategic documents. They provide the overall line with the general sustainability concept, directed towards the proper balance between the three core pillars. Commonly, the focus is placed on those issues concerning the proper use of natural resources, while recognizing solid institutional capacities for sustainable tourism development [66–68]. Many additional plans and projects further address the process of development of tourist destinations of Serbia (like regional plans, tourist destination master plans, and municipal development plans). Still, policymaking in Serbia's tourist sector is in a transitional phase generally due to the bureaucratic and autocratic system. Political decisions regarding sustainable tourism were mostly modeled on EU policies, based on various EU strategic frameworks and effective instruments (the Territorial Agenda of the European Union in 2007 [69], the European Union Strategy for Sustainable Development in 2006 [70], and the Agenda for Sustainable and Competitive European Tourism in 2007 [71], etc.). In the National Strategy of Sustainable Development [64], the fundamental concept of sustainable development is overgeneralized. Here, tourism is identified as an emerging sector with significant environmental impact but short of precise objectives or priority actions to make it more sustainable [72]. There have been frequent changes in legislation in all domains. However, these documents typically represent bare plans and political statements with little possibility for realization, commonly overusing and misunderstanding the concept of "sustainability". Even if the development of general and sectoral plans/strategies and programs has been intensified, there was a notable lack of inter-sectoral coordination and cooperation [72]. Often, national policies and strategic documents were elaborated by third parties, frequently engaging foreign experts unaware of pivotal national concerns and the current situation at destination levels. Thus, questions are raised about the realistic possibilities and the justifications for their practical implementation. This highlights a need for the creation of cooperative stakeholder networks in the policymaking process. As the tourism sector involves a vast number of stakeholders, this should lead to a dialog and negotiations to develop commonly desirable policies [73,74].

4. Materials and Methods

As the focus of the study was to understand policy enablers' perception of the sustainable development of tourist destinations in Serbia, a multi-stage methodology was chosen. The study applied the scholarship research approach [75] and combined theoretical and practical knowledge. This involved collecting data from using a qualitative (expert's judgment and content analysis) and quantitative method (interviews). The study followed the three core elements of the sustainable tourism conceptual model [76], including a modest set of indicators extracted from the European Tourism Indicator System (ETIS) [77] (Figure 1). In this line, the research queries hypothesize impacts by surveying policy-enablers' opinions. Structural equation modeling (SEM) was applied, which represents the relationships and critical paths between the factors.

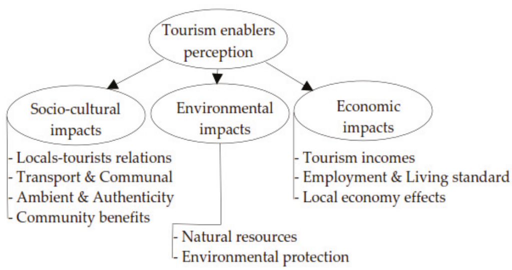

Figure 1. Conceptual sustainable tourism model and ETIS indicators. Source: adapted from [76,77].

A total of 219 half-structured deep interviews [78] were held in the local language with a conversation time ranging from 20–30 min. This included enumerators consisting of three researchers and six Ph.D. students performing interviews at different time stages, 3 h per each group (a senior and two students) daily (during the fair's working hours, 10–19 h). Each group had to mark the interviewees on the specially prepared list, which was transmitted to prevent overlapping. The interviews were conducted in the period February 22–25, 2018 at the International Belgrade Tourism Fair. The fair is considered one of the most important tourism events in Southeastern Europe and a gathering point for tourism providers at international and national levels. So far, various aspects of such fairs have been examined by scholars [79–83].

The interviews were undertaken by open-ended questions allowing the respondents to elaborate a freely structured discourse about the proposed topics, with minimal intervention to guide the process and perform quantification of responses. Before entering the interviewing process, a protocol was prepared. Piloting was performed to ensure the validity, clarity, and layout of the protocol. This also allowed the identification of possible omissions, irrelevant items, and determination of the time needed to finish the interviewing [84]. It was comprised of the following sections:

Section 1: Introduction. The research aim and the respondents' critical role in providing first-hand data were briefly explained.

Section 2: Perception (gathering quantitative data during the interview). A set of questions were asked to evaluate the policy with regard to socio-cultural, environmental and economic impacts (Figure 1). It comprised 12 selected ETIS sustainable indicators, as a sufficient base to assess the perception of policy enablers on revealing perceived sustainability level of tourist destinations [85]. The balanced number of driving forces, impact and response for all three basic sustainability levels was introduced. Neutrally phrased items were used to minimize ambiguity in interpretation [61,62].

Section 3: Enablers' policy and challenges (gathering qualitative data during the interview). The aim was to explore the challenges and the necessity of reform of tourism development in the destination.

Section 4: Interviewee data (Table 3).

Table 3. Interviewee data.

Data	% (∑ = 219)
Gender	
Male	35.6
Female	64.4
Age (years)	
18–35	46.6
36–60	49.2
60+	4.2
Education	
High school	12.7
University	87.3
Working position	
Manager	35.3
Employee	64.7
Institution	
Research unit	4.2
Municipal institution	66.4
Hotel & Other	15.1
Cultural center & Other	14.3
Policy level	
Local	79.0
Regional	8.4
National	10.9
International	1.7
Type of organization	
Public	85.6
Private	14.4

During the interviews, full notes were carefully taken and respondents were invited to describe their perception of the current status of sustainability of tourism destination. By choosing from a five-point Likert Scale (1 = strongly disagree to 5 = strongly agree) quantitative data were collected on the degree at which each interviewee evaluates the three sustainability pillars. Collected data were transferred and processed in SPSS 24.0. The research applied exploratory factor analysis (EFA) on 12 ETIS indicators to identify coherent factors that represent the underlying dimension. A principal axis factor with an oblique rotation (Promax) was chosen to accommodate the possible correlation among factors. Structural equation modeling (critical path analysis model) was applied to the sample of 219 respondents as the fully appropriate sample size [86–88]. The model represents the relationships between the factors within the socio-cultural, environmental and economic impacts in Serbian tourist destinations.

After collecting the quantitative data, the interview protocol consisted of another consolidated set of direct questions related to tourism development challenges. Qualitative data were also collected, as interviewees were asked to briefly explain their insights about the broad spectrum of policy issues. The objective was to determine their first-hand perception of policy perspectives on reform challenges and the necessity of intervention in the current tourism development agenda at a local level. Respondents were also asked to suggest the inclusion of any missed but relevant aspect in terms of tourism policy reform. The sentences they used, repetition, and their vigor of expression, led to overall expert judgment. Subjective assessment enabled concise summarization and comprehensive compilation of the judicial sentences and empirical generalization of findings and conclusion.

Following the interviews, content analysis of the existing strategic tourism development documents was conducted. The aim was to reliably detect whether they properly address the sustainability issues typically identified by the respondents and systematically and objectively identify any possible inferences [89]. As sources were used national strategic planning documents (National Strategy on Sustainable Development [64] and the Strategy of Tourism Development [65]), regional development plans, tourist destinations' master plans, and municipal tourism development plans. They serve as a basis on which many decisions are made for tourist destinations. An assessment was carried out based on the extent to which existing strategic documents addressed issues of sustainability concern to policymakers, and how frequently they referred to the topics raised by the interviewees.

5. Results

Table 3 presents the full data of the interviewees' profiles. The target group consisted of representatives at all levels of tourism policy organizations: local (79%), regional (8.4%), national (10.9%) and international (1.7%). They were identified as the main policymakers for fostering an environment for sustainable development of tourist destinations. The respondents were managers (35.3%) and employees (64.7%) of public (85.6%) and private organizations (14.4%) retaining a comprehensive image of the tourism development process in Serbia. Specifically, they worked in research centers and universities (4.2%), municipal institutions such as tourist organizations and offices (66.4%), hotels and other establishments (15.1%) and cultural and other associations (14.3%). The respondents came from 79 municipalities, covering about 60% of all local tourist organizations in Serbia. There was strict domination of females (64.4%) and highly educated respondents (87.3% with university diploma). Almost half of the respondents (49.2%) were between 36–60 years old, followed by those aged 18–45 years (46.6%), and there were only 4.2% older than 60.

To explore the critical factors affecting the level of sustainability of tourist destinations in Serbia, respondents were invited to rate their level of agreement with sustainability indicators. Based on EFA, Table 4 presents the measurement variables for each impact factor in the form of a brief item providing sufficient internal consistency. A principal axis factoring was conducted with Promax rotation to determine the dimensionality of indicators. The total variance explained by three distinctive dimensions was 51.562%, being moderate enough. This is satisfactory, particularly in tourism studies where information is often less precise [90]. The overall Cronbach's alpha value of the indicators was 0.83, which is above the suggested benchmark of 0.6 [91]. The Kaiser-Meyer-Olkin value of sample adequacy was 0.634, being classified as a mediocre [90,92]. Bartlett's test is significant ($p < 0.05$) indicating the factor analysis is appropriate.

Socio-cultural sustainability indicators show a Cronbach's alpha value of 0.776 and explain 45.265% of the total variance. This impact represents two factors (Table 2, numbers F1 and F2) and both dimensions have high mean values. Each feature was set for further sub-dimensions. Thus, the first factor of the "Socio-cultural environment" has a Cronbach's alpha of 0.744 and a mean of 3.68 and consists of three items (social equity, authenticity of the destination, and cultural richness). The second socio-economic factor, "services", has a notably high Cronbach's alpha of 0.807 and a mean of 3.32, and consists of two items (transport services and communal services).

The second dimension, "environmental sustainability", and the third dimension, "economic sustainability", reflect with just one factor. The environmental sustainability produces a Cronbach's alpha of 0.882 and explains 55.463% of the total variance; the mean value is 3.16, and it consists of two items (natural resources of the destination and local community involvement in environmental protection). Economic sustainability includes three items (economic viability, employment quality, and local prosperity). This explains 53.959% of the total variance, with a high Cronbach's alpha value of 0.832, but the lowest mean value, 2.76. The policy enablers dimension records a high mean value of

3.79, and might be considered a factor with a vital role in monitoring and managing of sustainability of tourist destinations.

Table 4. Tourism factors.

No	Item	Loading/Cro Alpha	Mean	Std. dev	Std. Error Mean	t	Sig. (2-Tailed)
	SOCIO-CULTURAL IMPACTS	0.776					
F1	*Socio-cultural environment*	0.744	3.68				
6	Social equity	0.730	3.59	0.964	0.065	7.301	0.000
7	Authenticity of the destination	0.727	3.90	0.793	0.054	7.310	0.000
10	Cultural richness	0.774	3.57	0.942	0.064	7.451	0.000
F2	*Services*	0.807	3.32				
8	Transport services	0.807	3.33	0.973	0.066	5.558	0.000
9	Communal services	0.807	3.31	0.916	0.062	7.610	0.000
F3	ENVIRONMENTAL IMPACTS	0.882	3.16				
1	Natural resources	0.882	3.17	0.929	0.929	9.810	0.000
2	Local community involvement in environmental protection	0.882	3.15	1.027	1.027	10.052	0.000
F4	ECONOMIC IMPACTS	0.832	2.76				
11	Economic viability	0.832	2.99	0.938	0.063	9.218	0.000
12	Employment quality	0.819	2.71	1.006	0.068	9.376	0.000
13	Local prosperity	0.845	2.59	1.102	0.074	9.688	0.000
	POLICY ENABLERS	0.900	3.79				
3	Monitoring sustainability of tourist destination	0.900	3.76	1.049	0.071	10.515	0.000
4	Managing sustainability of tourist destination	0.900	3.82	0.977	0.066	10.097	0.000

Extraction method: principal axis factoring. Rotation method: promax with Kaiser normalization.

Figure 2 presents the path analysis model indicating the relationships between the factors within the socio-cultural, environmental and economic impacts in Serbian tourist destinations. Some relations may be easily misinterpreted if respondents' answers are not properly addressed. Although it is logical to expect that transport and communal services may produce positive economic effects, here it is not the case. However, the respondents' distribution on the issue addressing the economic impacts explains the negative correlation. Namely, a substantial number of respondents expressed neutral perceptions on employment quality assessment, vis-à-vis the largest number of negative impressions concerning local prosperity issues. Similarly, one may explain the policy enablers' correlations. Questions concerning monitoring and managing of the sustainability levels at a destination also recorded mostly neutral statements. A negative assessment of 38.3% was evidenced in the case of evaluating the monitoring process, and 38.9% for assessing the management aspect of sustainability at destinations.

Table 5 presents the goodness-of-fit measures. Accordingly, the model fit was found very satisfactory, since all fit indices were above the cut-points [90]. The chi-square is significant, and, in comparison with the sample size, the ratio χ^2/df has a value lower than 5. Both CFI and IFI are above 0.9. RMSEA is slightly over 0.05, and SRMR is well below 0.8.

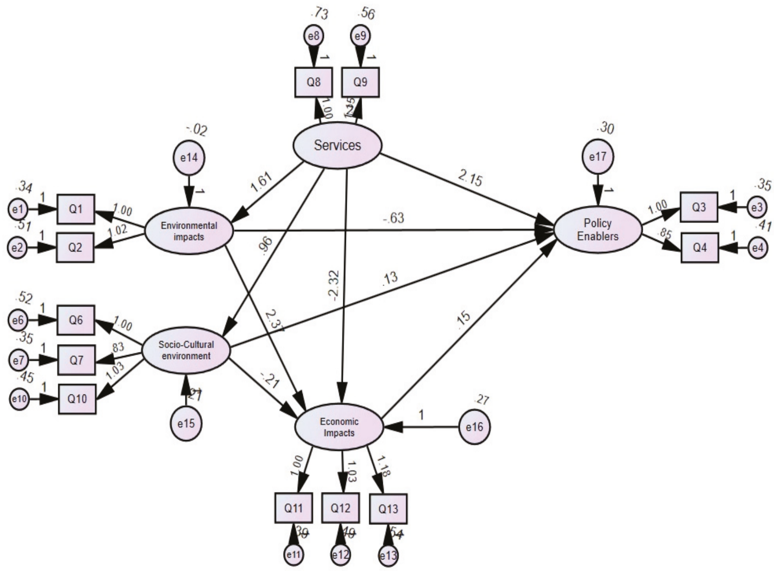

Figure 2. Path analysis model results.

Table 5. Goodness-of-fit measures.

χ^2	p	df	χ^2/df	CFI	IFI	RMSEA	SRMR
111.2	0.000	45	2.47	0.929	0.931	0.063	0.552

6. Findings and Discussion

The research findings are elaborated in a two-fold manner. Firstly, the study assessed the policy perspective concerning the level of perceived sustainability of tourist destinations in Serbia. Secondly, upon the scholarly research approach, the study found many new insights for reforming current tourism development as well as some strategic challenges.

Assessing possible factors affecting the level of sustainability of tourist destinations in Serbia by policy enablers revealed that socio-cultural impacts are perceived as the most beneficial. Socio-cultural aspects like authenticity and uniqueness of destination act as the most relevant factors for sustainable development. As argued in [93], the cultural image often mediates environmental and economic perceptions at the destination level. Tourism policymakers outline that Serbian tourist destinations should focus on cultural values as an input of harmony, originality, and embrace of opposites, as argued by [94]. However, appropriate attention must be placed on the fact that cultural sensitiveness of tourist destinations calls for consistent monitoring. This also stands for social equity and cultural richness.

Surprisingly, the environmental factor was identified as having a medium impact for sustainability, unlike the notation in strategic documents, where the sustainable use of natural resources is strongly emphasized [65]. The ecological setting is found to be extremely fragile and sensitive [95], so the environmental sustainability (physical integrity, diversity, resource efficiency, environmental purity) was found hard to be perceived as the leading factor. Furthermore, the interviewed policymakers have recognized that environmental issues can be properly addressed only at higher development levels. Namely, tourism development in most destinations in Serbia is still small-scale and directly associated with socio-cultural factors and limited infrastructural capacities.

Although the dynamic economic environment makes it important to conduct monitoring of economic sustainability (employment, viability, local prosperity), policy perception on this issue has not researched the tipping point. Respondents indicate that policies are still primarily focused on issues related to infrastructure, product design, and marketing, and far less on supporting economic viability and facilitating local prosperity. This may jeopardize the wellbeing and livelihood of locals [96]. Therefore, it is essential to provide economic benefits to ensure locals' motivation to support tourism activities and preserve the destination's natural and cultural environment [24,51,97].

These categories are standardized and emerge as basic sustainable tourism principles, relevant to the destination's development. Consequently, these organizations are mostly concerned with planning for the present and future. However, such perceptions should be taken as personal and conceptual since what is perceived as sustainable practice differs between people and locations [98]. Since the parent theme was sustainable development, policy enablers highlighted the issue of re-shaping strategic documents to achieve access to sustainability. Even more, a concern that current tourism is focused solely on maintaining the number of tourists without taking care of responsible controlling has been raised. Tourism is commonly perceived to be on a maintainable level, although sometimes poor in quality, leading to a perception that support and coordination at all levels of policymaking are lacking. There is also a significant discrepancy in attitudes on prioritizing actions to improve the competitive position of Serbia in the international tourism market between the private and public sectors [23].

There is a general lack of cooperation between institutions and a reduced level of consolidation of different development goals, plans, and projects. Coordinated actions of defined stakeholders are missing, as they frequently exhibit a competitive rather than cooperative attitude, which is regarded the main obstacle in reaching sustainable development goals [22,99]. The role of local communities in the decision-making process is still extremely marginalized in Serbia, affecting perceived sustainability. Understanding the policy perspective allows current developing strategies to be assessed and re-shaped for their effectiveness and relevance to be developed. The qualitative analysis suggests changes in the policy context in a way to better embrace the key principles of sustainability [100]. The findings indicate a common belief that currently tourist destinations in Serbia are managed in a maintainable rather than in a sustainable manner. This means tourism is not operating at its optimum level, which flings a shadow of pessimism about the possibility to achieve sustainable grounds. As increasing tourist numbers in the destination remains an everlasting strategic goal, it simply confronts the sustainability principles. It was uncovered that, currently, policymakers are focused on sustaining some partial elements necessary for tourism development (such as ambient, authenticity, services, etc.), hence contributing merely to maintain the environmental quality [101,102]. This concept stands and works only in the short-term, unlike sustainability which represents a long-term, proactive and holistic approach [103]. This requires a change in perception, since sustainability no longer represents a strictly ecological concern (as in the case of strategic documents), but rather tackles a range of environmental, social, economic and other issues.

When comparing the results of content analysis of strategic tourism documents and personal perceptions of respondents, some overall convergences and divergences appeared. In terms of similarities, the same general perception that tourism in Serbia offers numerous benefits for tourist destinations and consequently should be positively acknowledged was uncovered. Similarities were also revealed in expressions of distress about the process of monitoring tourism product quality. Yet, rather than prevailing perceptions, several differences were noted, and a slight deviation occurred. Since tourism development documents typically reflect the broad concerns, the results suggest that they appeared to be less concerned with achieving sustainability than the interviewed policymakers. Namely, the documents contain directions focused on gaining positive impacts, omitting the essential elements of sustainability. Hence, they pose many so-called 'strategic areas of intervention', which were determined as primary concerns for enabling tourism growth. As such, current strategic documents lack the substantial element of the main definition of sustainability—enhancing local opportunities for the future [85]. This represents the main concern of policymakers when interviewed in person.

To summarize, the content analysis illustrated that current development plans and policies did not reflect real policy enablers' perceptions, but rather reflect those for just supporting maintainable tourism. The integral development component is missing as a key factor in reaching sustainability.

Ultimately, such a maintainable pattern may result in almost immediate positive tourism effects. However, sustainability will not exist until it is managed in such a way that differs from general policy directions [104]. This means that reforming current policy orientation is inevitable, which will lead to the inclusion of a broader perception as a crucial advantage in understanding and practicing sustainability. Indeed, until perceptions are thoroughly incorporated into strategic documents, management and monitoring of resources in tourist destinations in Serbia may continue to be perceived as unsustainable. This means tourism will most likely continue its development process without reaching general sustainability goals. As such, it may inevitably lead to exploitation and eventually deterioration of destinations and local resources.

7. Conclusions

This study examined the perceptions of policy enablers and explored the main challenges for tourist destinations in terms of sustainability. It has found that socio-cultural impacts are perceived as important for achieving sustainability when developing tourist destinations in Serbia. It also suggested a model that presents the relationship between factors within socio-cultural, environmental and economic impacts. It assists in monitoring and managing tourism activities and their impacts. As the model is developed in the case of Serbian tourist destinations, every generalization of the proposed model must consider that issues of sustainable development may vary from one place to another. There is a need to formulate place-specific policies with the ability to recognize the particular context of sustainability at the local level [56,105]. Implementing this model provides a possibility for managers and policy enablers to detect sustainability problems in a given tourist destination. The model also assists comprehension of how to initiate and carry out informed decisions with the aim of ensuring the destination's sustainability [37]. In the absence of such a framework, it would be challenging to identify issues and areas of intervention, and eventually duplicate efforts and waste resources. This enables a much smoother way for decision-makers to perceive the interconnection between the factors of influence and prioritize the action areas. As such, policymakers can be proactive in identifying problems and bridge the gap in due time.

The research confirmed that tourist destinations in Serbia need to re-shape their development plans and policies. As noted by [50], the accent should be on guaranteeing the social sustainability of the destination, unlike current policies that are missing that element. Thus, although it is declared for strategic documents that they foster tourism development by contributing to its sustainability, it was confirmed that they do not provide a broader picture. Conversely, such plans and documents manage the status quo to keep up with short-term impacts, staying focused predominantly on the quality of the product. Such an approach is increasing the risk of inappropriate monitoring and management at the destination level.

Several limitations were noted for this research, which may be addressed in some future work. Initially, data collection was performed during a tourism fair at an extremely busy time, so the perception of respondents might be a bit neglected. Second, the interview involved a rather limited set of sustainable indicators, opening the possibility for further expansion. Third, the sample was taken based on convenience sampling, so probability sampling techniques may be further introduced. Fourth, the study explored the case of Serbia and provides the most effective 'micro' solution to what remains essentially a 'macro' problem. Ultimately, the research departed from the conventional triple bottom line of sustainability, so some additional dimensions of sustainability might be included. Adding the aspect of institutional sustainability may broaden understandings on local planning policy, local-oriented control policy, political participation, political support, etc. The total variance explained may also be improved beyond the current moderate level of 51.562%. Nevertheless, the study presents a broad context of tourist destinations' sustainability and enables a better understanding of the current policy level attitude.

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preparation, B.P.; writing—review and editing, B.P. and A.T.; visualization, B.P. and C.A. All authors have read and agreed to the published version of the manuscript.

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Review

Do Local Food Products Contribute to Sustainable Economic Development?

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Abstract: Local food production benefits sustainable regional development and should be considered as one the pillars of sustainable regional development strategies. Local food producers share a common heritage because of the cultural and historical ties in their regions, while consumers tend to value food products produced locally. The purpose of this article was to explore market participants' attitudes toward the impact of local food product attributes on sustainable regional development. The authors' findings on the main advantages and barriers to consumption of local food products have pointed out the complexity of the relationships between market participants (i.e., producers and consumers) and indicated that a deeper understanding is necessary for overall economic development. The problems of local food products in Serbia, in the context of sustainable regional development, have not been investigated so far, and for this reason, it is important to analyze the differences between consumer and producer attitudes to reduce this perceived gap in the literature. In this way, these insights can offer opportunities for strategic actions in regard to the local food product supply and consumption, with the aim of including different regional stakeholders.

Keywords: sustainable regional development; local food products; producers; perceptions

1. Introduction

In the Republic of Serbia, there is a growing interest in and increasing consumer demand for high-quality and healthy products. The intensification of local food products' (LFPs) production would contribute to halting biodiversity loss and improving ecosystems, and on the other hand, would help towards improving the economic positions of farmers, who form the basis of sustainable local development, and are directly related to the achievement of UNESCO's (United Nations Educational, Scientific and Cultural Organization) second, 12th, and 15th sustainable development goals [1]. The leading activity of the population in the Republic of Serbia, especially in rural areas, relies on agriculture and support for local development, which also represents the fight against poverty and hunger. However, the integration of agricultural production with the secondary and tertiary sectors is needed, which will ensure a higher degree of marketability of agri-food products. The role of agriculture in the development of society is significant [2], whether in terms of local development or sustainability of resources. The ultimate goal of enhancing LFPs' production should be the greater utilization of available natural resources [3], processing capacity increase, and improvement of the social position of the population. It is well known that every country has its own path and strategy for local development and that not every strategy is a guarantee for success, and therefore countries exhibit different degrees of economic development.

Unlike economically-developed countries where scientific research on local produce has been present for a relatively long time, in less developed countries or countries in transition, this concept is only beginning. In the Strategy of Agriculture and Rural Development of the Republic of Serbia for the period 2014–2024 [4], it is stated that the share of agriculture in total employment in the Republic of Serbia is very high and amounts to over 20%, with a high number of family farms using up to 2 ha of agricultural land (48.8% of the total). These farms account for about 8% of agricultural land. By moving the boundary of utilized land to a higher group (up to 5 ha), it appears that agricultural holdings of this size, although they make up 78% of the total, represent only 25.3% of the area. As Cvijanović and Ignjatijević [5] point out, the transition process has led to the creation of a monopoly on the agricultural market on one hand, and on the other, direct producers have not adapted to the new market order and have remained unorganized and unprotected. For significant improvements in production, small producers lack necessary capital, expertise, and modern equipment (since the value exceeds the financial capabilities of individual producers). It is for this reason that local food producers tend to produce the same products for years, in the same way, although they are not satisfied with the selling prices and earnings.

In recent years, consumers in the Republic of Serbia have shown an increased interest in value-added food products; the findings on the Serbian WTP (willingness to pay) for organic products show that consumers are willing to pay a premium price for organic products, up to 20% [6]. In light of the future development of the local food system in Serbia, it is important to identify and understand the determinants of consumer and producer behaviors in Serbia's local food system in relation to the general patterns identified already in the literature. This process requires detailed information on consumer and producer attitudes and their decision-making processes connected to the purchase and production of local food products. The perceptions and beliefs towards local food products from the point of view of consumers and producers in the Republic of Serbia have not been investigated so far. The inclusion of local food producers in the study is important, especially for countries in the early stages of local food system development. There are no previous surveys on local food systems relating consumers' and producers' data simultaneously. Therefore, the specific objectives of the current study were to: (1) Investigate the current perceptions of local food products in the Republic of Serbia; (2) determine if the perceptions of consumers and producers of local food products differ; and (3) analyze the perceived impact of local food product attributes on sustainable regional development. After the introduction, the conclusions of a number of authors, who have analyzed the various aspects of LFPs, have been presented. This segment of the paper represents a special contribution because it highlights the views and recommendations of authors of different economic, political, and cultural beliefs. As there is no previous research on local food systems in Serbia, the results obtained in this research may be of special interest to authors and researchers, members of the SME (Small and medium-sized enterprises) sector, educators and representatives of advisory services, and government bodies. In the following section, the authors present the methodology and the research results. Finally, the concluding observations summarize the research findings. In particular, we emphasize that our findings can serve as a starting point for the creation of further strategies for the development of the LFPs sector.

2. Literature Overview

Early research on the consumption of local products emerged after the development of farmers' markets amid growing consumer concerns about food safety and the use of environmentally-friendly products [7–9]. In the United States, Canada, and Europe, smaller-scale localized production has become a part of community and economic development strategies [10,11]. On the other hand, local products have been associated with a social component of sustainable production and community economic development [12]. The term "local" has been associated with many interpretations, encompassing attributes commonly ascribed to locally-grown produce (such as freshness, environmental sustainability, and support of the local economy). However, Born and Purcell [13] have speculated that the "local trap", i.e., the tendency of food activists and researchers to assume that locally-sourced produce is desirable (for reasons of ecological sustainability, social justice, democracy, better nutrition, and food security, freshness, and quality), and as such should be preferred a priori to larger scales of production, may pose significant risks to food systems research [14]. Karner's [15] findings on local food systems in five countries (Austria, England, Hungary, France, and Poland) have shown that an alternative local food network represents an emerging European sector. The term "local food" can be linked to a concept of natural goods or services produced or provided by different enterprises in rural areas with an established socioeconomic identity [16]. La Trobe [17] points out that in the UK, local food products are regarded as produced and sold within a 30 to 40-mile radius of the market, or more if the market is situated in a large urban area (such as the Islington market in London which has a 100-mile radius). On the other hand, the consumers show great variation in the distance they consider to be local and this distance may differ in case of fresh and processed products [18]. The findings of a survey of 120 food consumers, trying to define the term "local" food on the basis of several meanings (such as distance, physical accessibility, and "specialty" or "uniqueness" criteria) have shown that the most common meaning for the term "local" food was "foods grown locally" [19].

From a demand-side viewpoint, Feldmann and Hamm [20] have analyzed 73 research studies on local food (coming mostly from the USA, UK, Germany, and Italy) revealing some common characteristics of local food shoppers such as being older and wealthier, living in rural areas with the predominant expectation that the local food was tastier and of higher quality and not perceived as expensive. Mirosa and Lawson's [21] findings show that behavior of those consumers who express a strong intention to purchase local food is strongly related to the types of food they eat, how they cook their food, and where and when they eat it. Hu, Batte, Woods, and Ernst's [22] findings on what is local and how important the local production is for different food categories reveal that female consumers have higher demands that the food should be produced nearby, while higher income households and more highly educated consumers are less demanding of shorter food traveling distance. Older consumers, married and with children, also more often tend to value more local production.

Brown's [23] findings on Missouri household interest in purchasing locally produced foods show that quality and freshness followed by price influenced the purchase, although the majority of consumers were not willing to pay a premium for locally grown food products. Carpio and Isengildina-Massa's [24] findings on consumers' willingness to pay for locally branded products show that if food products were equally priced, the majority of consumers (95%) would choose state-grown produce over out-of-state produce. The consumers who purchase local products for the reason of support of local farmers have a higher willingness to pay a premium. Consumers who use direct channels (farmers markets, community supported agriculture outlets, and roadside stands) reported a significantly higher WTP for local produce [25]. Grebitus, Lusk, and Nayga's [26] findings show that that the belief to support the local economy when buying food that traveled fewer miles affects positively not only the consumers' WTP but also the consumers' perceptions that fresh local food has superior attributes compared to food that traveled more miles. Gracia, De Magistris, and Nayga [27], by simultaneous experimental auction, elicited consumers' WTP for a local lamb meat and tackled the issue of social influences ("the importance consumers attach to the purchase of food products produced in the region where they reside using traditional and typical production methods" p. 3) and the effect of consumers' gender on WTP for local food products confirming their hypothesis that social influence indeed affects WTP values and that women get an extra utility from the satisfaction of buying locally produced lamb meat. Nganje et al.'s [7] findings show that local produce bearing the Arizona Grown label had a higher WTP than local produce labeled USDA-certified (U.S. Department of agriculture). In their research on whether local and organic products are complements or substitutes, Gracia, Barreiro-Hurlé, and López-Galán [28] show that consumers are willing to pay a positive premium price for an enhanced method of production as well as for the proximity of production.

Research studies in today's local food markets have tried to reveal not only a consumer behavior perspective on local food but also the perceptions of producers who are selling local food products through established direct marketing channels [29]. Many researchers accredit the success of local food to determining adequate channels of direct marketing such as farmers markets (FMs). Gregoire, Arendt, and Strohbehn's [30] findings show that local producers sold vegetables more frequently than meat items. The findings of Gao, Swisher, and Zhao [31] show that the most important reasons why consumers shop at farmers markets are freshness and locality of production, the availability of organically grown produce, and knowing the farmers. The findings of Feenstra, Lewis, Hinrichs, Gillespie, and Hilchey [32] point out that the majority of vendors that are small-scale enterprises with less market and business experience tend to sell at markets closer to their farms.

Veidal and Falten's [33] findings reveal that most of the farm entrepreneurs (the majority of them being female) used at least two other direct marketing channels to distribute local products besides FMs, such as their own farm shop or farm gate sales, restaurant and catering outlets, while their main motives for selling at FMs were direct feedback from consumers and the enjoyment of selling directly to consumers. Conner, Colasanti, Ross, and Smalley's [34] findings show that the primary motives for shopping at farmers markets were food quality, safety from foodborne illness, and the ability to support local farmers, while the least important motives were the availability of pesticide-free or hormone-free foods. The findings of the study of Schneider and Francis [35] on consumers' and farmers' opinions have revealed that Nebraska farmer interest in producing for local markets was low, but on the other hand the consumers showed high level of interest in purchasing food from farmers' markets, local grocery stores, local restaurants, and directly from farms, with a willingness to pay a price premium for local foods. The most important factors for purchasing food brands or products was quality and taste followed by nutritious properties/ healthy attributes, price, and environmentally friendly production. Support a local family farm, Nebraska grown, locally produced were also perceived as important factors.

The findings of Hunt [36] on farmers market consumer and vendor data simultaneously, have revealed that female postsecondary educational level consumers with a higher income shop at farmer market. The findings of Hardesty [37] point out that the institutions will rather buy local products if they can bear the higher transaction costs. Gregoire and Strohbehn's [38] findings show that one-third of schools purchase food directly from local producers (in Minnesota, Iowa, Nebraska, and Kansas; and Slovakia [39,40]), mainly as a benefit to maintain good public relations, to support the local economy, to buy fresh foods in smaller quantities, to be familiar with the product sources, and food safety.

The findings of O'Hara and Pirog [41] accentuate the need for establishing better research methods through improving data collection, performing studies on larger geographic scales that also include the recent changes in diet and quantify other economic attributes of local food systems (besides the number of jobs). The findings of Abatekassa and Peterson [42] reveal that local independent retailers (compared to wholesalers and supermarket chains) still tend to consider local foods as a potential source of competitive advantage and for this reason they have better relationships with selected local producers than the large chains. The findings of Matson and Thayer [43] point to the emergence of food hubs, which could be very useful instruments for more efficient local food supply chains with a need for further research on their characteristics and economic impact on food systems.

3. Materials and Methods

The research in this study covered the producers and consumers of local food products (LFPs) in the country, where there are large differences in educational level, purchasing power, and consumer preferences. The questions that arise are: What is the current perception of local food in the Republic of Serbia? Is there is a difference in the perception of consumers and producers of local food? What is the impact of local food products on sustainable economic development? Drawing on previous research from Memery, Angell, Megicks, and Lindgreen [44] and Megicks, Memery, and Angell [45], and suggestions from representatives of the Bačka Development Agency and the Institute of Food Technology in Novi Sad (due to involvement in similar research), the perceptions of two groups of respondents were investigated. By comparing the similarities, i.e., differences in the perception of LFPs, it is possible to examine their views, draw conclusions and recommendations which can be used for the purpose of local development, overcoming developmental inequality, increasing employment—in short, economic development. A lot of studies have been focused on the analysis of production, on volumes, costs, i.e., quantitative indicators and the analysis conducted so far in Serbia have neglected the perceptions of individuals. Considering that the perception and beliefs on local food products in Serbia have not been researched so far and that in recent years consumers in Serbia have shown an increased interest in value-added food products [6], the subject of research is to provide new insights into producers' and consumers' views on LFPs and their impact on sustainable economic development.

The research was carried out on the territory of Republic of Serbia in several cities and villages, from March 2019 to July 2019. The total number of LFPs consumers investigated was 1000 and the total number of LFPs producers was 500. Of the distributed questionnaires, 834 LFPs consumer questionnaires were returned complete (83.4% response rate). As for LFPs producers, 312 distributed questionnaires were returned complete (62.4%). The first group of questions included data on the socio-demographic characteristics of consumers (gender, age, education). The second group of questions consists of 30 claims, directly or indirectly related to local food product attributes rated on a five-point interval scale (1 is the lowest grade and 5 is the highest). The questions were modeled on a survey by Memery et al. [44] and Megicks et al. [45]. The survey was anonymous, the respondents were selected according to the "snowball" principle, and the distribution and completion of the survey was conducted electronically. The respondents /producers have been selected as follows: The Development Agency Bačka and the Institute from Novi Sad have at their disposal a database of LFPs producers. The questionnaire, or link of the questionnaire, has been sent to their email addresses asking them to forward it to the key informants thus ensuring a chain of possible other producers to be included in the study. The authors believe that the technique has been adequate to find as many respondents as possible, especially since the respondents have not been randomly selected from the whole population, but have been selected based on their professional orientation and desire to participate in the research [46].

On the other hand, the snowball method as a random sampling technique has been applied in regard to the LFPs consumers. The researchers, after having identified the initial seed informants within the researchers' professional and personal network, have asked the potential respondents to forward the link to their contacts [47,48]. Based on the experience of other researchers, the snowball method has proven particularly useful in exploring under-researched topics—such as LFPs consumer preferences, where respondents are difficult to locate and when the knowledge and awareness on the product is not sufficiently explored [49,50]. Data processing was performed using the SPSS program for statistical data processing. Descriptive statistics, factor analysis, and standard multiple regression were used to analyze the phenomena in detail. The purpose of our research problem was to find an equation that best predicts the dependent variable as a linear function of the independent variables therefore the multiple regression was applied [51–54].

4. Results

Descriptive statistics show that of the 834 respondents the majority of LFPs consumers were female (58.27%), while in the sample of LFPs producers the majority of them were male producers (52.6%). Female consumers were more willing to participate in the research and were more interested in providing responses on their perceptions and beliefs toward the local food products they were buying. The average age of the consumers is in the age group of 21–40 years old (63.4%), while in the sample of producers the average age belongs to the group of 41–50 and 51–60 years old. The majority of consumers and producers have a high school diploma (Table 1).

Table 1. Socio-demographic characteristics of the sample.

		Consumer (n = 834)	Producer (n = 312)
Gender (%)	Men	41.73	52.6
	Women	58.27	47.4
Age (%)	21–30	40.05	8.33
	31–40	23.38	8.33
	41–50	16.43	33.33
	51–60	8.75	25.00
	<21	7.07	0.00
	>60	4.35	25.00
Education (%)	High School Diploma	38.25	50.00
	Higher Educational Diploma	26.14	4.17
	College Diploma	23.62	29.17
	Post-Graduate Qualification	8.87	12.50

Source: Author's calculation.

For the consumer sample the mean score for 30 aspects ranged from 3.05 to 4.41. At the top of the list are aspects relating mainly to LFP attributes: Good taste (4.41, standard deviation—SD 0.815), healthy (4.35, SD 0.884), good quality (4.15, SD 0.884), good appearance (4.00, SD 0.941), image (3.92, SD 1.02), followed by promotion (3.63, SD 1.04), and packaging (3.53, SD 1.077). Although the perceived LFPs' availability on the market mean score was slightly above the mid-point score of 3 (3.59, SD 1.026), the consumers are of the opinion that LFPs do prevent the disappearance of traditional foods (4.13, SD 1.02), further promote gastronomic culture (4.10, SD 0.939), and contribute to the preservation of local production techniques (4.09, SD 0.933). The consumers are of the opinion that LFPs contribute to the promotion of local communities (4.03, SD 1.015), protect the diversity of tastes (4.09, SD 0.94), and increase public interest in local methods of production (3.97, SD 1.023). The consumers are of the opinion that the state encourages LFPs production (4.03, SD 1,016), but not enough, that is, that the state does not have a defined LFPs technological process (3.41, SD 1.144), and that direct sales to some degree enable producers to avoid paying taxes (3.52, SD 1.182). The results indicate that the consumers are of the opinion that not all producers have a complete LFPs production process (3.94, SD 0.994), and that LFPs are not subject to the same phytosanitary control as other types of conventional products (3.51, SD. 1.045). LFPs are perceived as rather expensive (3.74, SD 0.887), not stored in an adequate manner (3.60, SD 1.027), which all together has a limiting effect on the perception of quality, that is, consumers are of the opinion that not all LFPs have a quality guarantee (3.70, SD 0.968). The results indicate that direct contact with producers is not very important to consumers (3.96, SD 1.119), and that there is no clear view regarding the difference in quality and price between domestic and imported LFPs (3.05, SD 1.002).

For the producer sample the mean score for 30 aspects ranged from 2.00 (imported LFPs are of better quality than the domestic LFPs) to 4.68 (producers are of opinion that LFPs contribute to the promotion of gastronomic culture). At the top of the list are aspects relating to LFPs' promotion of gastronomic culture (4.68, SD 0.695) and attributes such as good taste (4.51, SD 0.826), healthy (4. 63, SD 808), good quality (4.54, SD 0.623), good appearance (4.42 SD 0.863), image (4.08, SD 0.863). They are perceived by producers as not expensive (3.39, SD 0.986). The producers are of the opinion that individual LFPs are not adequately stored (3.00, SD 0.227) and that packaging (3.50, SD 0.959) and promotion (2.88, SD 1.203) of LFPs can be improved. The results of the research indicate a high level of awareness of producers on the importance of LFPs: For the protection of taste diversity (4.54, SD 0.866), for the prevention of the disappearance of local foods (4.42, SD 0.863), for the promotion of consumption of LFPs (4.38, SD 0.906), for the promotion of local communities (4.32, SD 1.004), for the preservation of local production techniques (4.17, SD 0.944), and for the public interest in local methods of production (4.00 SD 1.26). Thus, the respondents considered their LFPs to be of good quality, but their mean scores on the LFPs institutional framework were rather low: Not all LFPs have a quality guarantee (3.38, SD 0.973), implemented phytosanitary controls (3.29, SD 1.209), and defined local production technological process (3.09, SD 1.296). Producers are of the opinion that there is not enough systematic support from the state (4.00, SD 1.446). From the producers' point of view imported LFPs are not safer (2.08, SD 1.354), cheaper (2.04, SD 1.062), or of better quality than domestic LFPs (2.00 SD 1.26). The domestic LFPs' market availability is scarce (2.42, SD 1.354) and their placement on the market is rather difficult (2.42, SD 1.224). It is interesting to conclude that producers and consumers have the same attitude about mutual contact—they think that it is not significant, and that producers are not interested in direct contact with buyers of their products (resellers/intermediaries or directly with consumers).

When the mean scores are compared between both stakeholder groups (Figure 1), the producers evaluated more positively the quality, price, and safety of the domestic LFPs in regard to imported LFPs. On the other hand, the consumers evaluated more positively the current LFPs' placement on the market and LFPs' availability, so we can conclude that consumers are currently satisfied with the LFPs' availability on the market. The producers' mean scores are higher with regard to the following statements: LFPs promote gastronomic culture; LFPs protect the variety of local tastes; LFPs promote the consumption of local products; therefore we can conclude that producers tend to value more their contribution to support the local community. The producers' mean scores of LFPs appearance, quality, image, and health attributes are slightly higher than the consumers' which reflects the need for further promotion of these products and their local production process to diminish the perceptual gap.

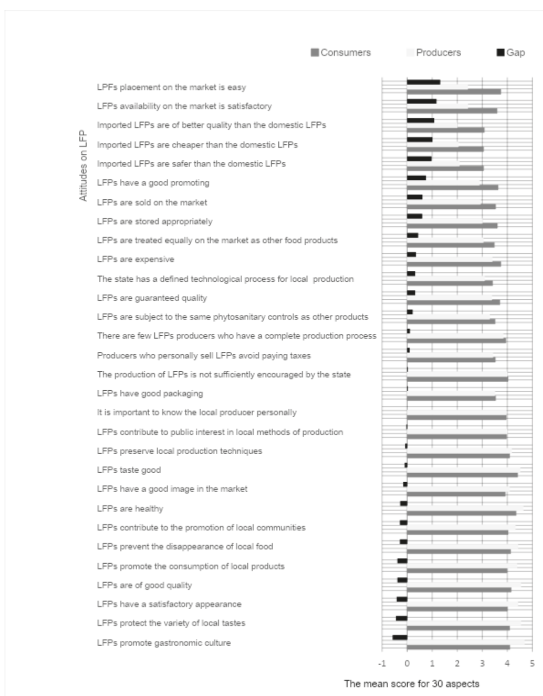

Figure 1. Graphical representation of mean scores of consumer and producer attitudes on local food products (LFPs).

4.1. Analysis of Consumers' Attitudes towards Local Food Products (LFPs)—Factor Analysis

As a next step, the authors wanted to analyze whether for a collection of observed variables there is a set of factors that can explain the interrelationships among those variables, by means of unified factor analysis. The factor structure matrix presented in Table 2 contains factor loadings that represent the correlation coefficients between the extracted factors and the variables and indicates the importance of each variable for a single factor [55,56]. Data were processed in the statistical package SPSS for Windows, version 22. In order to examine the latent structure of consumer attitudes on LFPs, factor analysis with the principal component method was applied. As the Kaiser-Meyer-Olkin measure of sampling adequacy was satisfied (KMO = 0.931), Bartlett's test of sphericity was significant (χ^2 = 15,618.91; $p < 0.000$) therefore the factor analysis was conducted. Using the Cattell scree criterion, five factors were retained. Based on saturation in the assembly matrix and analysis of the internal consistency of the questionnaire, it was decided to exclude three items from the further analysis, which had saturations below 0.40 and whose exclusion increased the coefficient of reliability. To achieve a simple structure, the factors were rotated with Varimax rotation. Factor scores were established, and we calculated the Cronbach's reliability coefficient for each factor. Cronbach's reliability coefficients are 0.923, 0.890, 0.791, 0.723, and 0.714.

Table 2. Exploratory factor analysis for drivers of buying LFPs.

	Factors				
	1	**2**	**3**	**4**	**5**
X1 Intrinsic and extrinsic LFPs attributes (IPIQ)					
LFPs taste good	0.798				
LFPs are healthy	0.771				
LFPs have good quality	0.742				
LFPs have good promotion in the market	0.593				
LFPs have a satisfactory appearance	0.614				
LFPs have a good image in the market	0.592				
LFPs have good packaging	0.434				
LFPs are expensive	0.434				
X2 Local support (LS)					
LFPs protect the variety of local tastes		0.779			
LFPs prevent the disappearance of local food		0.759			
LFPs preserve local production techniques		0.752			
LFPs promote gastronomic culture		0.779			
LFPs promote the consumption of local products		0.729			
It is important to know the local producer personally		0.656			
LFPs contribute to public interest in local methods of production		0.623			
X3 Market characteristics (MC)					
There are few LFPs producers who have a complete production process			0.672		
LFPs availability on the market is satisfactory			0.623		
LFPs placement on the market is easy			0.618		
X4 Institutional challenges (ICH)					
LFPs are stored appropriately				0.815	
LFPs are subject to the same phytosanitary controls as other products				0.814	
LFPs are sold on the market as other food products				0.807	
The state has a defined technological process for LFPs production				0.551	
Producers who personally sell LFPs avoid paying taxes				0.562	
The production of LFPs is not sufficiently encouraged by the state				0.416	
X5 Existence of substitutes (SUB)					
Imported LFPs are safer than the domestic LFPs					0.910
Imported LFPs are of better quality than the domestic LFPs					0.889
Imported LFPs are cheaper than the domestic LFPs					0.826
Initial eigenvalues	10.979	3.744	2.209	1.679	1.423
Percentage of variation cumulative	32.29	11.01	6.49	4.94	4.19
Cumulative percentage	32.29	43.30	49.80	54.74	58.93
Cronbach's alphas	0.923	0.890	0.791	0.723	0.714

Source: Author's calculation.

Taking into account the saturation shown in the circuit matrix (Table 2), the obtained factors are grouped into five units. The first factor accounts for 32.29% of the variance in the model (eight items), the second factor for 11.01% of variance (seven items), the third factor for 6.49 % of variance (three items), the fourth factor accounts for 4.93% of variance (six items), and the fifth factor with three items accounts for 4.18% of variance in the overall model. Squared factor loadings:

- The first factor shall be labeled 'intrinsic and extrinsic LFPs attributes' (IPIQ) and within that factor three statements, with the highest factor loadings (0.788, 0.771, and 0.742), most accurately describe it. The squares of the indicated correlation coefficients represent the variance proportions of certain variables that are attributed to the effect of a given factor. The squared factor loadings, for the most significant statements within the first factor, explain 63.68%, 59.44%, and 55.06% of the variance of the factor named 'intrinsic and extrinsic LFPs attributes.'
- The second factor shall be labeled 'local support' (LS) and within that factor as many as five statements, with the factor loadings (from 0.729 to 0.779) accurately describe it. The squared factor loadings, for the two most significant statements, explain 60.68% of the variance of the factor named 'local support' (from the consumer point of view).
- The third factor shall be labeled 'market characteristics' (MC) and within that factor all three statements have the factor loadings (from 0.618 to 0.672) and the squared factor loadings that explain 38.19%, 38.81%, and 45.16% of variance of the factor named 'market characteristics.'
- The fourth factor shall be labeled 'institutional challenges' (ICH) and within that factor three statements, with the highest factor loadings (0.807, 0.814, and 0.815) describe it most accurately. The squared factor loadings for the most significant statements within the fourth factor explain 66.12%, 66.26%, and 66.42% of the variance of the factor named 'institutional challenges.'
- The fifth factor shall be labeled 'existence of substitutes' (SUB) and within that factor only one statement has a very high factor loading (0.910) which describes it. The squared factor loading for the most significant statement within the fifth factor explains 82.81% of the variance of the factor named 'existence of substitutes.'

4.2. Analysis of Producers' Attitudes towards LFPs—Factor Analysis

In order to examine the latent structure of the relationship between the variables of producers' perceptions toward the local food, factor analysis with the principal component method was applied. The Kaiser-Meyer-Olkin sampling adequacy which should be greater than 0.5 for a satisfactory factor analysis (KMO = 0.925) and Bartlett's test of sphericity was significant (χ^2 = 1432.54, $p < 0.000$), therefore all the assumptions were fulfilled in order to proceed with the analysis. Three factors were retained using the Cattell scree criterion and rotated with Varimax rotation. Based on saturation in the assembly matrix and analysis of the internal consistency of the questionnaire, it was decided to exclude from the further analysis two items, which had saturations below 0.40 and whose exclusion increased the coefficient of reliability. Factor scores were established, and we calculated the Cronbach's reliability coefficient for each factor. Cronbach's reliability coefficients are 0.915; 0.867, and 0.762, respectively.

Taking into account the saturation shown in the circuit matrix (Table 3), the obtained factors are grouped into three units. The first factor accounts for 39.24% of the variance (12 items), the second factor contains explaining 22.38% of variance (six items), the third factor explains 12.66% of variance (10 items) in the overall solution.

- The first factor can be labeled 'intrinsic and extrinsic LFPs attributes and local support' and within that factor four statements, with the highest factor loadings (0.886, 0.839, 0.831, and 0.809), describe it most accurately. The squared factor loadings for the most significant statements of the first factor explain 78.50%, 70.39%, 69.06%, and 65.45% of the variance of the factor named 'intrinsic and extrinsic LFPs attributes and local support.'
- The second factor can be labeled 'institutional challenges' and within that factor two statements, with factor loadings (0.744 and 0.669), accurately describe it. The squared factor loadings for the

two most significant findings explain 55.354% and 44.756% of the variance of the factor named 'institutional challenges' from the manufacturers' point of view.

- The third factor can be labeled 'market characteristics and existence of substitutes' and within that factor the three statements have factor loadings (0.724, 0.669, and 0.616) and squared factor loadings of for the most significant statements that explain 52.42%, 44.76%, and 37.95% of the variance of factor named 'market characteristics and existence of substitutes.'

Table 3. Exploratory factor analysis for drivers of produce LFPs.

	Factors		
	1	**2**	**3**
X1 Intrinsic and extrinsic LFPs attributes and local support			
LFPs promote gastronomic culture	0.886		
LFPs have a satisfactory appearance	0.839		
LFPs taste good	0.831		
LFPs have good quality	0.809		
LFPs protect the variety of local tastes	0.790		
LFPs prevent the disappearance of local food	0.789		
LFPs are healthy	0.766		
LFPs preserve local production techniques	0.701		
LFPs have a good image	0.669		
LFPs contribute to public interest in local methods of production	0.386		
LFPs have good packaging	0.499		
LFPs promote the consumption of local products	0.484		
X2 Institutional challenges			
LFPs guarantee quality		0.744	
It is important to know the local producer personally		0.669	
LFPs are stored appropriately		0.505	
Producers who personally sell LFPs avoid paying taxes		0.451	
The state has a defined technological process for LFPs production		0.426	
LFPs are subject to the same phytosanitary control as the other products		0.424	
X3 Market characteristics and existence of substitutes			
Imported LFPs are safer than the domestic LFPs			0.520
LFPs have good promotion in the market			0.557
LFPs are expensive			0.306
LFPs placement on the market is easy			0.724
Imported LFPs are cheaper than the domestic LFPs			0.669
LFPs availability on the market is satisfactory			0.616
Imported LFPs are of better quality than the domestic LFPs			0.572
LFPs are sold on the market as other food products			0.517
There are few LFPs producers who have a complete production process			0.438
The production of LFPs is not sufficiently encouraged by the state			0.423
Initial eigenvalues	13.24	7.27	4.29
Percentage of variation cumulative	39.24	22.38	12.66
Cumulative percentage	39.24	66.16	78.82
Cronbach's alphas	0.915	0.867	0.762
Extraction method: Principal component analysis. Rotation method: Varimax with Kaiser normalization.			
a. Rotation converged in 11 iterations.			

Source: Author's calculation.

4.3. Standard Multiple Regression

With the aim to identify if the perceived local food product perceptions influence the sustainable regional development the respondents are also asked to evaluate the claim: "Local food products contribute to sustainable regional development" (five-point interval scale question), which has been used as a dependent variable in the regression analysis. The data were analyzed using a multiple regression procedure, while the set of factors obtained in the factor analysis for each sample group were used as predictors. By performing the multiple regression, the authors wanted to search and explain the relationship of the independent variables to the dependent variables if those relationships prove to be linear [57–59].

Firstly, a standard multiple linear regression was performed on the consumers sample. Before the regression was performed, we tested the assumption that the independent variables are not highly correlated with each other (r = 0.7 and above) [60]. Tolerance values are greater than 0.7, and VIF (variance inflation factor) values are not greater than 10, confirming that there is no multicollinearity. Model evaluation was then undertaken. Multiple regression has been conducted to determine the best linear combination of all factors for predicting local food products contribution to sustainable regional development. The empirical level F of the distribution is 123.015 and indicates that the high value of F distribution is not accidental, and that the regression equation is applicable. This combination of variables significantly predicted LFPs' contribution to sustainable regional development, with all five variables significantly contributing to the prediction in the consumer model. The beta values are as follows: The largest coefficient indicating which independent variable has the greatest influence on the dependent variable is found in the local support factor—LS; followed by institutional challenges—ICH; intrinsic and extrinsic LFPs attributes—IPIQ; while market—MC and substitutes—SUB have a weak negative impact. The adjusted R squared value was 0.426. This indicates that 43% of the variance in LFPs' contribution to sustainable regional development was explained by the model. The beta weights, presented in Table 4, suggest that in the consumer sample the local support factor contributes the most to predicting LFPs' contribution to sustainable regional development.

Table 4. Standard multiple regression.

Factor	Consumers		Factor	Producers	
	Unstandardized Coefficients (Standard Error)	**Standardized Coefficients**		**Unstandardized Coefficients**	**Standardized Coefficients**
(Constant)	0.942 (0.152)		(Constant)	4.141 (0.302)	
IPIQ	0.167** (0.030)	0.164	IPIQ & LS	0.104** (0.058)	0.099
LS	0.439**(0.030)	0.431	ICH	0.169** (0.044)	0.214
MC	−0.082** (0.029)	−0.082	MC & SUB	0.025 (0.055)	0.036
ICH	0.280** (0.027)	0.304			
SUB	−0.010 (0.022)	−0.013			
Y_{LR} = 0.942 + 0.167 IPIQ + 0.439 LS − 0.082 MC + 0.280 ICH − 0.010 SUB			Y_{LR1} = 4.141 + 0.104 IPIQ & LS + 0.169 ICH + 0.025 MC & SUB		

** Correlation is significant at the 0.01 level (2-tailed). Source: Author's calculation.

In order to conduct a multiple regression on the producers sample, a collinearity test was performed and, when all the assumptions were met, a multiple regression was applied. The empirical level F of the distribution is 5.744. The beta values are as follows: The largest coefficient indicating which independent variable has the greatest influence on the dependent variable is found in the institutional challenges factor, followed by intrinsic and extrinsic LFPs attributes and local support factor, while the market characteristics and existence of substitutes factor has no statistically significant effect. For the producers sample, the combination of variables significantly predicted LFPs' contribution to sustainable regional development, with two variables significantly contributing to the prediction in the producers' model. The adjusted R squared value was 0.53. This indicates that 53% of the variance in LFPs contribution to sustainable regional development was explained by the model. The beta weights presented in Table 4 suggest that in the producers' sample the institutional challenges factor contributes the most to predicting LFPs' contribution to sustainable regional development.

5. Discussion

Consumers' and producers' perceptions toward local food have been analyzed according to the 30 claims which were considered as relevant to provide a basis of consumers' and producers' interconnection in this developing market. In general, a rather complementary concept was found, given the similar ranking of perceived rating scores of these aspects. From the mean scores we can see that the consumers attributed the highest mean scores to LFPs' attributes such as good taste, health, good quality followed by local community support, such as the prevention of the disappearance of local food and promotion of gastronomic culture. Similarly, the producers attributed the highest mean scores to the promotion of gastronomic culture, LFPs' attributes such as health, good quality, protection of the variety of local tastes, and good taste. The producers' mean scores are slightly higher with regard to the LFPs' contribution to support to the local community and LFPs' attributes which reflects the need for increased LFPs promotion and education of consumers on LFPs' advantages to diminish the perceptual gap.

By the means of a factor analysis, the authors have grouped the claims in several factors, such as intrinsic and extrinsic quality, local support, institutional challenges, market characteristics, and existence of substitutes. The conducted factor analysis shows that the highest percent of variance in the factor analysis model in the consumers sample is found in the first two factors, intrinsic and extrinsic LFPs attributes and support of local community. It is precisely the first group of factors that shows that consumers have a positive perception of LFPs (taste good, healthy, of good quality, with good promotion and image in the market, a satisfactory appearance and good packaging). In particular, this work adds to the findings of Megicks et al. [45] that the significant drivers of positive purchasing behavior concerning local food are being motivated also by supporting local communities, retailers, and producers. The support for local farmers and traders and desire to eat high-quality traditional products that may not be found in supermarkets may be determinants of support for local food [15]. These results also confirm the findings of Colasanti, Matts, and Hamm [61] showing that the primary motives for local schools to purchase local food were local community support.

On the other hand, the consumer perception of LFPs which denote the attribute of food safety of a local brand needs to be further explored. The existence of food safety or quality assurance is of particular importance as the consumers expect quality assured LFPs, providing them with quality validation through standardization of production, regulated storage and control as "it is believed that credence attributes such as 'food safety,' 'traceability,' 'certification,' and 'brand' should positively impact consumers' perceived utility and consumers' willingness to pay a premium" [7] (p. 21). As such, there is a clear need for government regulatory environment involving the LFPs food safety and quality assurance. Building local food systems can help local economies to grow and yet improve the overall social well-being of local communities [62]. The findings of Donald and Blay-Palmer [63] on Toronto's innovative creative-food industry (defined as SMEs locally grown, organic, specialty, or culturally appropriate food) point out the disconnection between the growth of the creative-food industry and the government regulatory regime that promotes agri-food. The authors Christensen and Phillips [64], by using four theories (social capital, conflict theory, symbolic interaction, and rational choice), have further explored the possibility to bridge the gap between local food systems and community economic development. Finally, the results confirm that the local support factor as a predictor of perceived LPFs contribution to local economic support was statistically significant in both samples (of LFPs consumers and producers). For these reasons, the local producers should be further motivated to access a potential market which offers them the opportunity to sell direct to the customer, adding value to the product, and in the future possibly widening the LFPs range. Consumers should be further educated to support local producers, possibly creating a direct link with the producer. The production of a high-quality, branded product with a geographical indication would affect the recognition of the particular area [65], increasing the income and standard of living of the producer, involving all members of the community, developing teamwork, and ultimately preventing migration to urban areas or other countries [66]. Balázs [67] emphasizes that in post-socialist contexts new emerging types of local food systems (LFSs) can be developed through collaboration within the local food sector and the researcher can help the translation process and knowledge sharing between various stakeholders who can shape LFSs' development standards (quality criteria, advertising, logos, labels, and regional trademarks) or solve legal, production, management, and commercial difficulties. In particular, the findings of Deller et al. [10] show that local foods development should be specific to a community that addresses the needs of producers and consumers and not precisely replicable as it is tailored to a specific location. "Most municipal/local governments and community planners have only recently begun to view agricultural and food systems as an important engine of economic development and sought to link their economic development and assessment work to local food systems activities" [68] (p. 4). The local food system can contribute to local employment as labor-intensive practices involved in local production techniques are present. Authors' findings show that "local food production may create jobs as well as stimulate proportionately larger spillover impacts on the local economy than nonlocal production. The results show that profitable local food producers exist across all sales classes and market channels, signaling there are viable business models for a variety of farms and ranches to pursue within this niche" [69] (p. 2). The findings of Rossi, Johnson, and Hendrickson [70] using IMPLAN (The Impact Analysis For Planning) model, reveal that the magnitude of economic benefits from local food systems depends on the region, and survey data show that total contribution to local GDP by local food systems was greater than the contribution of conventional food systems. The research of Sharp et al. [71] on understanding the opportunities and impacts of local food and farming development indicated that successful development efforts would contribute to positive economic impacts [72]. By using a local food impact calculator that can assist local food system practitioners in estimating the economic impact of their project, the authors have investigated which other sectors in the local economy are impacted by local food operations as well as other economic and nonfinancial benefits that may occur when local food systems are expanded [73,74]. On the other hand, the authors' [75] findings that direct-to-consumer (DTC) agricultural production impacts the food services and beverage subsector show the economic linkages between local agricultural production and food retail sectors. Boys and Hughes [76] suggest that the extent to which customer willingness to pay for locally grown foods surpasses the cost advantage of non-local products will influence the future market size for local products while the economic, environmental, social, and health impacts of LFS measured by the regional economics tools may account for public or attract private investment.

6. Conclusions

The results indicate that the LFPs perceptions in the samples of consumers and manufacturers have a rather analogous interpretation and, on the other hand, their mean scores slightly differ in some aspects, which has also been expected. This study, however, provides more substantive outcomes for the producers, processors, retailers, and consumers as it reveals local food products perceptions on various specificities. These include not just local food products' extrinsic and intrinsic attributes but some additional facets of demand and supply such as existence of an adequate institutional framework, improved credence attributes, and stronger brand image in order to be able to better differentiate these types of products. Interestingly, both the producers' and the consumers' perceptions on domestic LFPs, in relation to imported LFPs, are very positive as they consider domestic LFPs to be of better quality, safer, and cheaper than the imported food products, supporting the thesis that LFPs represent the potential that can contribute to the promotion of the local community. Consumers tend to pay more for the "value added" products and if the LFPs denote quality, freshness, and authenticity the local producers can in this way differentiate from large producers. The issue of trust that can be built between consumers and producers by a mutual contact shall contribute to healthier and more sustainable local community practices.

The importance of a local brand should be emphasized through targeted promotion programs. In this way consumers can be further educated on the benefits of LFPs. Branding programs that promote and identify local food products produced within the province may be a part of economic development strategies for rural communities. This is only possible if the local food producers are positioned differently from other large food producers, and if LFPs have adequate support and promotion in the framework of a rural strategy.

In the Republic of Serbia, the framework of community and economic development strategy based on LFPs is still in an early stage of development. The successful practices of local food systems in the European Union can facilitate learning and information exchange. The European countries have the support from European Agricultural Fund for Rural Development (EAFRD). The Republic of Serbia still has limited funds for rural support but has adopted rural development programs that include modernization of agricultural holdings, development of competitiveness, sector integration, innovation, market orientation, and encouragement of entrepreneurship. In order to strengthen local food system development, during the EU accession, local farmers with small farm size (well below the EU average farm size), with lack of financing, sales and marketing skills, administrative and trading cost burdens, need to have support from official bodies at regional and local level, in order to create local food systems that may have long term implications for community economic development, environmental sustainability, and nutrition. The multifaceted issue of local food products in the future could then also be reviewed from an economic perspective, such as to estimate the net economic impacts of local food systems. The research results reflect the segment of LFPs in the Republic of Serbia. As the LFPs market in the Republic of Serbia gradually develops, it is necessary to further investigate and monitor the development of this market and perhaps further investigate the willingness to pay for domestic LFPs compared to imported LFPs, and the willingness to pay higher margins for specific LFPs categories. On the other hand, it would be useful to investigate the degree of competitiveness of LFPs producers (their marketing skills, entrepreneurial skills, economic viability of financial incentives).

This research study is based only on qualitative and quantitative study of the representative sample of LFPs' consumers and producers in the Republic of Serbia, therefore its findings cannot be generalized to a wider range of developed agri-food economies, as the Republic of Serbia's local food system is in the early stage of development. This limitation of the study can point to the need to undertake further studies in comparable economies at a similar stage of local food system development.

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Conflicts of Interest: The authors declare no conflict of interest.

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Review

Perspectives of the Moldavian Agricultural Sector by Using a Custom-Developed Analytical Framework

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Abstract: Moldova possesses the largest area of farmland as a share of its total land surface, an advantage which should encourage economic development strategies oriented towards the agriculture sector. Government subsidies and agriculture loans have been used as tools for developing the Moldavian agriculture. However, considering the challenges generated by both climate change (the drought from year 2012 that affected 80% of farmland) and a difficult political situation (restrictions imposed by the Russian Federation on the Republic of Moldova's agri-food imports and exports between 2013 and 2014), the country's agricultural system ranks very low when it comes to agricultural production efficiency. The present paper analyses the performances of the agricultural sector and its impact on the Moldavian economy over a nine-year period (between 2008 and 2016), by using a custom-developed analytical framework based on a dataset containing 21 relevant indicators. The analytical framework generates various perspectives that can be used to elaborate an economic sustainable development strategy of the Moldavian agriculture sector. The development of the analytical framework is based on the dynamics of agriculture subsidies, agricultural loans, the agricultural sector's gross domestic product (GDP) and gross value added (GVA), as well as the dynamics of agricultural production and production value, also considering the main crops belonging to the Moldavian agriculture sector. The results are presented as sets of mathematical regression models that quantify the relationships found between the relevant agricultural parameters and their impact on the economics of the agricultural sector. It has been identified that the agriculture sector has a considerable impact on the Moldavian economy, a fact revealed by the significant model between the agriculture GVA and total GVA and GDP. A significant, negative correlation model was identified between agriculture subsidies and agriculture loans, although a small percentage of Moldavian agriculture farms were subsidized. Strong correlation models were also identified between wheat and maize production and total agriculture production, emphasizing the importance of these two crops for the Moldavian agricultural economy. Grape and maize production values also generated a correlation model, emphasizing the market interconnection between these crops It can be concluded that the increase in value of governmental agriculture subsidies, as well as expanding their addressability in order to maximize the access possibility for a higher number of agriculture farms, are essential for the Moldavian agriculture sector's future development, since considering the limiting value of and accessibility to subsidies, a direct correlation model was identified between governmental agriculture subsidies and agriculture GVA.

Keywords: GDP; GVA; subsidies; agriculture; analytical framework; Moldavian economy

1. Introduction

The agricultural sector is considered key in the national economy of the Republic of Moldova. Moldavian agricultural development is heavily influenced by a favorable mild climate with very-high-quality soils that allow the production of high-value crops like fruits and vegetables. Still, even in a very-high-quality soil context, Shik et al. [1] mention in their studies that large-scale agricultural companies, which are also the core of the export activities, produce mostly low-value-added crops (such as sugar beet, oilseeds and cereals) on farms that exceed 50 ha of land. The same authors also notice that the agricultural sector of the Moldavian Republic was characterized by significant changes over the last years, especially related to its modernization and development.

The dynamic character of this sector has manifested during the past decade and can be attributable to a large variety of factors, such as disruption of production, distribution networks enhancement, climate change (there is no other economic sector as exposed to natural hazards), economical strategies and globalization or investments dynamics. Subsidy development programs and the volume of investments are important indicators that characterize the state policy in the agriculture sector. For example, Valeriu et al. [2] highlights that in Moldova, during the period between 2006 and 2015, the volume of investments and subsidies in agriculture displayed pronounced annual growths and decreases, while evolving non-uniformly. In this context, agriculture subsidies can be considered measures for avoiding large annual fluctuations, being focused both on agricultural products with a high export potential and on those that are not covered completely by national production. Compared to the rest of the European countries, Moldova has a high agricultural potential. Indeed, having among the largest areas of farmland as a share of the total land (75.00% compared to the European average of 45%), it is still placed at the end when it comes to agricultural production efficiency [3].

Thus, the aim of this article is to analyze the Republic of Moldova's national agricultural sector during a nine year period, by developing an analytical framework based on several technological tools and a set of models containing agricultural indicators proved to be relevant (state subsidies, agricultural loans, gross domestic product—GDP, agriculture GDP, gross value added—GVA, agriculture GVA, main agriculture crops production and value of production) for identifying patterns and solutions that would lead to maximizing agricultural efficiency.

According to the IBM researcher Lieberman [4], an analytical framework is composed of several major components: a set of tools; a set of useful solution patterns; one or more model forms; and multiple research techniques. The present study followed this approach as it provides, by using several technological tools, a set of models describing the existing relations between the aforementioned parameters and several discovered patterns. The data we used in our research spans over 9 years; that is, between 2008 and 2016. Currently, there is a limited number of studies that would provide insights referring to the dynamics of the Moldavian agricultural sector over the past years.

In order to have a better understanding of the productivity aspect of the Moldavian agricultural systems, our analytical framework is also using a set of parameters related to agricultural gross value added. Gross value added (GVA) is strongly related to productivity as it measures the contribution to the economy of an individual producer, industry or sector.

In a study based on machine learning cluster analysis [5], different types of farms and their development level were delimitated based on certain economic aspects like GVA; thus, presenting an interesting aspect of the Moldavian agricultural sector—the existence of many small family farms and only a small number of corporate holdings that are accounting for most of the agricultural production.

Small individual farms predominantly produce solely for one or several family needs, unable to find their way to the market place, thus enforcing the rural economy.

Mainly, we consider that the low productivity of the agricultural sector is determined by the lack of investments, capital and available loan schemes, a context that led to the proliferation of low-efficiency technologies and the reduced use of fertilizers and pesticides—a situation confirmed by Shik et al. [1]. This situation clearly affects the welfare of the rural population of Moldova, population that is depending significantly on the agricultural sector.

As for the economic relations with the EU, the Republic of Moldova is the only country in the Commonwealth of Independent States that has preferential access to the EU market; thus, all the premises for the creation of free trade areas throughout the country were ensured. We consider that these free import zones could serve as liaison centers for capturing the foreign direct investments necessary to support the efforts of industrialization and subsequent development of exports, and the free zones for export offer a series of advantages for relocating certain industries originating from other countries in the host country.

In the Republic of Moldova, the agricultural sector supplies a large quantity of products for export, made up largely of raw unprocessed material at very low prices, while the import of agri-food products is comprised mainly of processed products. The size of the processing sector (excluding wine) is relatively small, at 4.50% of the total food and beverage industry in 2013 [6]. This situation is related to the lack of competitiveness that characterizes the Moldavian industry. Especially, this is the case with the food processing industry, due to low processing infrastructure (mostly limited to wine, apples and tomatoes). This manifested after 1989, when proper conditions for trade liberalization and import barriers reduction appeared.

The present research refers to the period between 2008 and 2016 and is based on data collected from agricultural farms, provided by the Moldavian National Bureau of Statistics and the Agency for Interventions and Payments in Agriculture, respectively. The period of nine years, between 2008 and 2016, was chosen since challenges generated by both climate change (the 2012 drought that affected 80.00% of farmland) and a difficult political situation (restrictions imposed by the Russian Federation on Republic of Moldova agri-food imports and exports between 2013 and 2014) were recorded. Therefore, by analyzing this period, a high-fidelity representation can be obtained, in order to assure a proper development strategy of the Moldavian agriculture sector, capable to face different environmental or political challenges scenarios.

For modelling purposes, the present study framework took into consideration the production values of the Moldavian main crops (wheat, maize and grapes), as they can be categorized from the information presented in Tables 1 and 2. By also calculating the productivity of the abovementioned crops, using the data presented in both tables, it can be concluded that both maize and wheat have similar average productivities (3.27 tons per hectare and 3.25 tons per hectare, respectively) during the four mentioned years (2015–2018).

However, according to recent studies [7], the grape and vegetable culture sectors are characterized by a large number of producers across the country that have important social impacts in addition to their strong economic impact, as they represent around 25% of the total agri-food exports. Vegetables were considered important crops as most of the production is obtained from greenhouses that require technological improvement and could benefit from subsidies and agricultural loans. The understanding of seasonality vis-à-vis competitors from other countries and their ability to spread marketing over time by using and improving greenhouses for vegetables could be a solution for increasing the performances of the agricultural sector [7].

Table 1. Sown area main crops (hectares) [8].

	2015	2016	2017	2018
Sown area - total	1502.60	1519.60	1532.90	1544.30
Cereals and leguminous crops	949.60	950.80	936.60	974.10
Wheat – total	345.50	371.30	335.60	373.10
Barley-total	84.50	83.20	80.70	65.00
Grain maize	492.70	468.00	481.40	491.40
Industrial crops	434.90	447.40	478.30	462.80
Sugar beet (industrial)	21.80	20.90	23.60	19.80
Sunflower	330.30	362.40	384.90	364.20
Soy	67.80	39.90	34.00	28.00
Tobacco	0.80	0.60	0.50	0.40
Potatoes, Vegetables, Melons, Gourds	57.30	58.90	57.10	53.40
Potatoes	22.20	20.70	19.70	19.00
Field vegetables	27.60	28.30	28.80	28.60
Forage crops	60.80	62.40	60.90	54.00
Fruit and berry plantations	110.40	110.10	113.40	113.10
Plantations of vineyards	128.80	129.10	120.70	126.90

Table 2. Gross harvest main crops (thousand tons) [8].

	2015	2016	2017	2018
Sown area - total	2206.40	2993.20	3354.80	3466.70
Cereals and leguminous crops	922.30	1292.90	1250.70	1162.80
Wheat – total	178.80	255.70	248.90	175.30
Barley-total	1076.80	1392.40	1772.50	2073.80
Grain maize	23.10	39.10	69.00	45.60
Industrial crops	484.80	677.10	803.80	788.70
Sugar beet (industrial)	47.90	42.10	46.50	57.70
Sunflower	537.50	664.80	876.30	707.20
Soy	47.90	42.10	46.50	57.70
Tobacco	537.50	664.80	876.30	707.20
Potatoes, Vegetables, Melons, Gourds	1.20	0.90	1.00	0.70
Potatoes	158.20	214.00	197.00	174.80
Field vegetables	245.80	293.30	309.70	283.30
Forage crops	54.50	66.50	56.10	46.10
Fruit and berry plantations	485.50	595.70	666.40	894.20
Plantations of vineyards	598.70	615.70	675.10	730.20

Moldova is a world-class producer of grapes, maize and wheat as a result of the European Neighborhood Program for Agriculture and Rural Development (ENPARD) partnership with the EU since 2013. This ranking has not changed since 2013, with two main producers being recognized, Moldova and Ukraine [6]. In 2017, Moldova was ranked first in terms of grape export in the ENPARD program, accounting more than 80% of ENPARD production [6]. In terms of grape production, in

Europe, Moldova ranks 11th and 20th in the world. Besides that, the Republic of Moldova is the country with the highest density of vineyards in the world.

Due to the continuous development of the Moldavian agricultural sector, funding needs are continuously growing. Farmers and companies alike want to buy new equipment, materials, fertilizers, quality seeds and new breeds, or want to expand their farm sizes. That is why the present paper's analytical framework considered several parameters that would potentially address this aspect, specifically subventions and loans. Regarding the subsidies allocated to agricultural farms, usually they were offered on the basis of the following two directions: 1) for the modernization of the agricultural sector, by subsidizing investment activities related to the creation of units for the handling and processing of agricultural production, the provision of the appropriate equipment, the supply of materials for agricultural crops, the establishment of vineyards and orchards and the development of agricultural services; and 2) to increase the competitiveness of the plant and livestock sector, by stabilizing the market and ensuring food security and income for farmers by allocating direct payments according to culture, animal species and average farm yield—depending on the area of agricultural land or the number of animals.

The financial support granted to the agricultural producers came through different sectorial programs, the state budget or external sources (Rural Investment and Services project; The Agricultural Revitalization Project IFAD-II; improving market access for grape producers in the South Center area—HEKS; technical assistance for young farmers regarding marketing and entrepreneurship—IFAD; etc.). However, the subsidy fund can be considered an instrument for unifying all programs and projects for agricultural producers.

Lastly, it should be emphasized that the agricultural economic situation is strongly related to agricultural sustainability as, according to the OECD, the definition of sustainable agriculture is agricultural production that is economically viable and does not degrade the environment over the long run [9]. The Committee for Agriculture of the Food and Agriculture Organization of the United Nations (FAO) [10], as well as other studies related to agriculture sustainability, also emphasized that changes in perceptions in relation to the interpretation of sustainable agriculture are emerging. Thus, the concept must extend to social, institutional and economic sustainability, and not exclusively environmental sustainability—the conservation and rational utilization of natural resources [11].

Agricultural sustainability can be defined as the state of four subsystems (economic, social, environmental and institutional) within which agriculture is operating [11]. Measuring sustainable development at an aggregate level, however, requires a broad integration of indicators of economic, environmental, and social changes.

Therefore, in order to make agriculture sustainable, the economic sustainability of this production sector must first be accomplished. General criteria of durable growth in agriculture should reflect mainly economic criteria, defined by economic efficiency, since the conception of sustainable agriculture includes the postulate of multifunctional development [12].

Thus, the present paper analyzes the performance of the agriculture sector and its impact on the Moldavian economy by using the custom-developed analytical framework in order to generate various perspectives that can be used to elaborate on an economic sustainable development strategy for the Moldavian agriculture sector.

2. Literature Review

The analysis of the performance of the Moldavian agricultural sector and its impact on the Moldavian economy was based on several scientific studies. The presented studies define the overall context while also describing relevant directions for the current research: a) the importance of the agricultural sector for the Moldavian economy; b) agricultural economical aspects like budgetary transfers to agriculture, agriculture as a strategic policy, agricultural funding in terms of subsidies and loans, budget sharing for agricultural research, irrigation, viticulture, and agricultural subsidy systems;

c) the chosen crops' importance; and d) agricultural modelling scenarios developed to obtain better insights over a country's agricultural sector.

Related to the importance of the agricultural sector for the Moldavian economy, Valeriu et al. [2] highlights that in the Republic of Moldova, agriculture represents an important sector of the national economy, which has changed dramatically over time due to a wide range of factors of which the most important are disruptions in the production and distribution networks. This sector is particularly exposed to climate change that primarily causes large fluctuations in agricultural production. In his research, Valeriu [2] analyzed the development evolution of the agricultural sector of the Republic of Moldova and formulated several recommendations to overcome existing problems.

The agriculture importance is also presented by Timofti et al. [3] which shows that the agrarian sector is of national interest. Considering his opinion, the agriculture should be an engine of economic growth and the state should ensure medium and long-term performance of the agricultural sector by the adoption of effective economic policy. For example, economic policies could refer to agricultural import and exports.

There are several research papers presenting relevant economical perspectives of the Moldavian agricultural system. As presented by Stratan et al., the agricultural sector was considered a strategic one by the Moldavian governments. His study shows that from 2012 to 2015, budgetary transfers to agriculture and rural development increased from 698 million MDL (Moldavian Leu) to 1093 million MDL. Considering the registered inflation rate of 4.65% in 2012 and 9.67% in 2015, reported by the Moldavian National Bank, it can be stated that Moldavian budgetary transfers to agriculture and rural development increased, in real value, by 49.42%. It was a growth driven by an effort to modernize agriculture as a strategic policy. In the same period, the volatility of the budget expenditures was very high with a decrease in spending in 2008 and 2010 [13]. A significant share of the capital spending facilitated an upgrade of obsolete infrastructure, while more efforts were dedicated to the sustainable use of natural resources and risk management. As the author describes, other agricultural budgetary expenditures were related to physical infrastructure and business development for the sector modernization and to key services, with significant allocations for food safety and agricultural education and a smaller share of the budget spent on research, irrigation, viticulture and wine development, as well as support of high-value markets and risk mitigation.

The funding of the Moldavian agricultural sector is presented as a critical aspect during the past years. In his research, Efros [14] presents the problems faced by the farmers concerning various forms of subsidies. In his opinion, the agricultural subsidy system should be constantly in the focus of executive authorities. Thus, agriculture subsidizing should be a mandatory aid for the agricultural development as well as a means of attracting investments in this area. Efros [14] identifies several objectives regarding the allocation of subsidy funds: (a) increasing the productivity and competitiveness of the Moldovan agricultural products on domestic and foreign markets; (b) stimulating technology transfer and extension services; (c) increasing the income of agricultural producers; (d) ensuring food security; (e) reducing the poverty level of the Moldovan population; (f) attracting young farmers for agricultural activities in rural areas; and (g) ensuring the efficient use of natural resources and environmental conservation.

By analyzing the investment climate in the Moldavian Republic, the top points and the weak points, Natalia and Artur [15] highlight that while investments are important for economies in transition, the agricultural sector of the Moldavian Republic has many problems and one of the most important is the lack of financial resources. In her opinion, this is the cause of why the agricultural sector gross value added declined in the 2000–2010 period. Minviel and Latruffe [16] also investigated public agricultural subsidies related to their impact on farm technical efficiency, and discovered that subsidies are usually negatively associated with the farm technical efficiency.

Sargo and Timofti [17], in their research, analyzed the efficiency of investment in agriculture and determined the optimal level of investment for 1 ha of agricultural land, while also identifying a serious issue represented by the inefficient management of funding sources. In addition, the author emphasized that the need for funding in the agricultural sector grew as agricultural enterprises were consolidating in order to sell the products on domestic and international markets. Farmers needed to buy tools and equipment necessary for optimizing their business. Heavy investments were also made in seeds or fertilizers that were imported, usually at high costs. As such, the need for financial resources registered a continuously upward trend. If referring to high import costs and international integration, Zbanca et al. [18] mentioned that the objective of Moldova's integration into the international economic system requires a qualitative change from the current situation in the food sector. For Moldova, this would mean that the entrepreneurs should focus on crop diversification and the production of agricultural products with high added value, as required for profitable markets. Adrian [19] analyzed the import and export trends between the Republic of Moldova and the EU, focusing on their influence on economic growth.

The performance of the Moldavian agricultural productivity in a larger context was presented by Csaki and Jambor [20]. In their paper, they analyzed the agricultural performance of the Commonwealth of Independent States (CIS) countries between 1997 and 2016 in order to identify whether the states' transitions brought positive changes in agricultural productivity.

Besides indicators like loans, subsidies, GDP and GVA, we also resolved to add to our proposed framework the production of several crops. As described above, the framework crops were chosen according to their impact on the sector. In terms of specialized literature, there are several studies describing crop importance for the agricultural system.

Zbanca et al.'s [18] research aimed to provide a comparative analysis of cultivation of high-value crops for enabling local entrepreneurs to correctly select their crops based on the economic indicators and financial resources. The authors developed financial models for each crop, with high-value production (particularly fruit and vegetables) that would lead to the highest profits.

In another study, Ursu and Petre [21] specified that the area of cultivated wheat in the Republic of Moldova increased during the period 2007–2018. In 2018, a total area of 373 thousand hectares was used, displaying an increase of 18.41% compared to 2007. Still, the highest value was registered in 2008. Namely, 400 thousand hectares. Ursu and Petre [21] show that the average annual growth rate over 12 years was around 1.55% annually. Statistically, from 2007 until 2018, 347.3 thousand hectares were cultivated annually, with a standard deviation from this average of 30.7 thousand hectares that represented a variation of 8.86%. Even if the wheat cultivated area increased, the production (1,286,332 tons (2008), 736,660 tons (2009), 744,160 tons (2010), 794,783 tons (2011), 495,231 tons (2012), 1,008,647 tons (2013), 1,101,682 tons (2014), 922,283 tons (2015), 1,292,921 tons (2016), 1,250,700 tons (2017), and 1,162,800 tons (2018)) actually decreased from 2008 until 2015, with the minimum being reached during the 2012 drought. There are several factors that could explain why in a context defined by the expansion of the cultivated area, the production actually decreased: a lack of infrastructure and machinery, a poor irrigation system as well as poor seed and fertilizer quality.

As for the area of cultivated maize, it is the largest of all the analyzed crops, displaying an average of 460,580 hectares, with a small yearly increase of 0.48%. In 2018, 491,000 hectares were cultivated with maize, 5.36% higher than in 2007 [21].

Grape production, another parameter of our framework, is also a significant element of the Moldavian agricultural sector. A number of interesting aspects can be found in several studies [22,23]. Thus, in 2018, the Moldavian vineyard covered an area of 148,500 hectares with a total production of wine estimated in 2016 at 1.7 million hectoliters. In the year 2018, the Republic of Moldova boasted as being one of the most significant grape-producing countries, ranking in the 19th position in the world.

In the Republic of Moldova, vineyards and the wine sector offer the highest number of jobs in rural areas: 29 679 legal entities being involved in this sector of the economy. In Moldova in 2018, there were 187 wineries registered in the Wine Register and 68 had their own vineyards. As such, the wineries own 36% of the total vineyard area.

As for investments, in 2018 the amount was around 20 million dollars: 10.5 allocated for planting, 4.7 for modernization, and 1.7 million and 0.23 million for various programs. Moldavian Republic is the country with the highest density of vineyards in the world, 65% of which planting white varieties and 35% red varieties [23].

Golban [24] presented the role and importance of financial services for the Moldavian horticultural sector, emphasizing the viticulture segment, in order to increase its competitiveness. He highlights that the modernization of the sector depends directly on the implemented financial services. His paper presents an analysis of the main financial services implemented in the horticultural sector (credits, subsidies and insurances) and the problems the farmers are encountering when accessing these services.

Besides research targeting the main agricultural crops presented above, there are also studies considering niche crops, like vegetables. Such an example can be found in the World Bank Report on the competitiveness in Moldova's agricultural sector [6], which focuses also on vegetables given its important economic impact, not only in terms of exports but also in the domestic economy. According to the study, there is a large number of small producers in this sector, meaning that the sector affects a large proportion of the population in the rural areas. This is also the sub-sector within agriculture in which most opportunities for increased competitiveness have been identified.

As our research presents, 2012 was an extremely difficult year for Moldavian agriculture as the Republic of Moldova suffered the combined impacts of poor rainfall and extremely high temperatures, which resulted in major losses in national crop production. Potopova et al. [25] shows that crop losses due to drought represent a complex issue as it involves the intensity, duration, and the developmental stage of the plants when drought occurs. In her studies, she investigated how to assess the drought-induced decline in crop harvest, as well as the drought variability and the yield sensitivity of winter wheat, maize, sugar beet and sunflower to such drought during their growth. Sutton et al. [26] identifies that the Republic of Moldova is one of the countries that is at a high risk due to climate change with the potential of having serious problems, as the majority of the rural population depends either directly or indirectly on agriculture for their livelihoods. In the same study, Sutton [26] highlights that, in the Republic of Moldova, drought can be one of the most severe natural hazards with extremely high economic and societal impact.

The scientific literature provides different modelling scenarios aiming to obtain better insights over a country's agricultural sector. Our study comes as an addition to the multitude of already developed models, as very few of them targeted the Moldavian agricultural sector.

As an example, we noticed the models targeting the relationships between the income per farm and the measurement of the farm performance. Kölling [27] performed surveys across different EU regions and investigated farmers' incomes and the way in which revenue data is used to evaluate Common Agriculture Policy (CAP) performance. After studying the farm sizes and income level of the agricultural population, Kölling [27] emphasized that these, along with the farm diversity, vary significantly. Actually, the averages used by the European Commission to compare incomes by farm size class, farm type and by region in FADN-RICA (Farm Accountancy Data Network—a data analysis tool designed to evaluate the income of agricultural holdings or farms and the impact of the Common Agricultural Policy) do not always demonstrate the extent to which certain groups of farmers are disadvantaged over others.

Another example of applied agricultural modelling can be found in Kern et al. [28], which presents a study in which multiple linear regression models were constructed to simulate the yield of winter wheat, rapeseed, maize and sunflower for the 2000–2016 time period in Hungary. He used meteorological data and soil water content as predictors, and based on a stepwise linear regression-like method, he obtained simple equations with well-interpretable coefficients. These could estimate crop yield with high accuracy. The explained variance was 67% for winter wheat, 76% for rapeseed, 81% for maize and 68.5% for sunflower. Holzworth et al. [29] also emphasizes the role of agricultural production modelling, with examples coming from all over the world, but focusing on different elements like environmental performance, greenhouse gas emissions, soil carbon changes, food security, pests and climate change. Yield prediction in Indian agriculture was studied by Sellam and Poovammal [30] in order to help farmers reduce their losses and to get the best prices for their crops. His research considered the analysis of environmental parameters, such as annual rainfall (AR), food price index (FPI) and area under cultivation (AUC), as they influence the yield of a crop; this in order to establish existing relationship among them. Similar with our proposed framework, Sellam and Poovammal [30] also used regression analysis (RA) to analyze the environmental factors and their infliction on crop yield. He considered the above parameters for a period of 10 years and established the relationship between the explanatory variables (AR, AUC, FPI) and the crop yield as a response variable.

Besides yield prediction models, like the one presented in [25], we also identified different studies, like [31], who aimed to model the impact of financial management performance on the agricultural enterprises of the Republic of Moldova by using nonparametric modelling of the economic efficiency.

Dubravka [32] also emphasizes that the share of gross value added by agriculture in the total GVA is one of the most important indicators regarding the importance of agriculture in the economic structure. By using linear regression methods, applied for examining the impact of GVA on Serbian agriculture and on total GVA, she showed that the movement of agriculture GVA has a statistically significant influence on the movement of total GVA.

Jones et al. [33] reviewed agricultural modelling, stating that modeling represents an essential tool in agricultural systems science and these days the "next generation" models, data and knowledge products are facing increasingly complex systems. In his opinion, the technological progress has strongly contributed to the evolution of agricultural system modeling, including the development of process-based bio-physical models of crops and livestock, statistical models based on historical observations, and economic optimization and simulation models at the household and regional to global scales.

It is also true that many models were developed and, as a consequence, there is also much redundancy. In his research, Janssen et al. [34] describes that agricultural modeling is suffering from fragmentation in model implementation. There are many models, much redundancy, models often being poorly coupled, and component re-use is rare. In this context, he considers that in order to improve this situation, an open, self-sustained and committed community could be formed that would develop agricultural models, associated data and tools as a common resource. All agricultural systems modelling should instantly absorb state-of-the-art technologies, best practices and standard operating procedures.

The information presented in the literature review section of the present research reveals the importance of agriculture in the Moldavian economy, emphasizing the need for developing this sector in order to assure proper, long-term, economically sustainable progress. This section also presented some of the main aspects which need to be improved in order to modernize the agriculture sector and to encourage current entrepreneurs, as well as to attract possible new investors. The information related to grape production and the wine sector reveals the importance of adopting governmental policies to encourage linking crop production with the food processing sector. The literature review section also reveals the novelty and importance of agricultural modelling, based on crop production and economic indicators, for assuring economically sustainable progress.

3. Materials and Methods

For analyzing the available data, we used Minitab software, together with the Python programming language and Spyder integrated development environment. Today, Python is one of the most popular programming languages because it is free to use and highly productive, compared to other programming languages like C++ or Java.

Furthermore, Python is one of the most-used languages for data analysis/analytics, machine learning and artificial intelligence, possessing an extensive set of libraries dedicated to these kinds of applications. For the current analysis, the Seaborn and SciPy library were used. Seaborn is a library built on top of matplotlib, integrated with pandas' structures, used for statistical graphics.

In terms of functionality, Seaborn offers multiple usages: an API for examining relationships between multiple variables, support for categorical variables, visualization of univariate or bivariate distributions, estimation and plotting of linear regression models, convenient views of complex datasets, built-in themes for matplotlib figures and color palettes for revealing patterns in data.

A second library used was SciPy, which is a component of an entire Python ecosystem for engineering, mathematics and science, comprised of six core libraries, namely, NumPy (base N-dimensional array package), SciPy (library for scientific computing), Matplotlib (2-D plotting), IPython (an enhanced interactive console), SymPy (symbolic mathematics) and pandas (data structures and analysis). The SciPy library that was used is a core package of the SciPy stack, providing user-friendly numerical routines for integration, interpolation, optimization, linear algebra and statistics.

The research analysis employed the specific functions used to minimize the objective functions for nonlinear curve fitting problems.

Due to the nature of the data, most of the curve fitting situations were related to the case in which polynomial terms were added in the linear regression, more specifically squared predictors. Typically, we choose the model order depending on the number of bends observed in our data plotting.

Each increase in the exponent produces one additional bend in the curve-fitted line. Still, we could not identify a situation that would require the cubic term or more than that. Besides, using polynomial terms as predictors, different scenarios included firstly testing the reciprocal (1/X) of the predictor variable in the model both as a linear and quadratic model and, secondly, transforming the variables with log or ln functions in the linear regression. A log transformation is a method that allows linear regression to be used for curve fitting, otherwise possible only with nonlinear regression.

As an example, the nonlinear function: $Y = e^{B0}{X_1}^{B1}{X_2}^{B2}$ can be expressed in the linear form of $\ln Y = B_0 + B_1 \ln X_1 + B_2 \ln X_2$.

The logarithm can be used on both sides of the equation (double-log form), or one side, known as the semi-log form. Log functional forms are powerful, but in the case where many predictors are involved, many combinations can be formed. For the current research, non-linear models were not proposed due to the low number of available data samples.

In order to test our model's goodness-of-fit in regression, we included in our research four residual plots, respectively, a normal probability plot of the residuals; a histogram of the residuals; residuals versus fits; and residual versus order.

A residual plot is represented by a graph that helps to determine if the OLS (ordinary least squares) assumptions are met, meaning that unbiased coefficient estimates with minimum variance were found. The normal probability plot of the residuals was used to verify the assumption that the residuals are normally distributed.

The histogram of the residuals determines whether the data is skewed or whether outliers exist in the data. Residuals versus fits verifies the assumption that the residuals have a constant variance, while the residuals versus order plot verifies the assumption that the residuals are independent from one another.

The analytical framework generates various perspectives, which can be used in order to elaborate on an economic sustainable development strategy of the Moldavian agriculture sector. Therefore, in order to identify the importance of agriculture sector for the Moldavian economy, the total GDP, GDP agriculture, GDP per capita, total GVA, GVA for agriculture and GVA per capita were included among the analyzed parameters of the present study. Thus, the GDP gives the economic output from the consumers side, while the GVA elucidates the state of economic activity from the producers' side or supply side. However, in order to characterize the sector in terms of financial input and production values, as well as production capacity, the value of the agriculture governmental subsidies, agriculture loans, main crops production quantity and production value were integrated among the analyzed parameters in the present study.

Wheat, maize, grapes and vegetables were crops considered as having considerable potential to influence the economic performance of the agriculture sector. In order to verify these, the total agriculture plant production and production values were integrated among the analyzed parameters. In addition, since only a small number of total agriculture farms manage to access the governmental subsidies, the value of the subsidies per subsidized farm was also considered to be included in the list of analyzed parameters, in order to offer a better result for the analytical framework, and thus more able to generate more accurate perspectives for sustaining the economic sustainable development of the Moldavian agriculture sector.

Our framework development was based on a dataset containing 21 parameters considered relevant, as previously explained in the introduction and further in the results section, and used here to describe the evolution of the agricultural sector during a period of nine years, between 2008 and 2016. The 21 parameters, statistically described in Figure 1, are as follows:

- Subsidies [Subsidies] (million $) (Source: FAO database [35]): the total value of governmental subsidies;
- Agricultural credits [Agr_Credit] (million $) (Source: FAO database [35]): the total value of agricultural loans;
- Gross Domestic Product [GDP] (million $) (Source: World Bank database [36]): total Moldavian gross domestic product
- Agricultural Gross Domestic Product [GDP_Agriculture] (million $) (Source: FAO database [35]): the gross domestic product produced by the agricultural sector;
- Gross Domestic Product Capita [GDP_Capita] ($) (Source: FAO database [5]): the Gross Domestic Product per Capita
- Farms Number [Farms_No] (Source: FAO database [35]): number of farms in Republic of Moldova that were subsidized;
- Farm Subsidies [Farm_Subsidies] ($) (Source: FAO database [35]): the value of subsidies per subsidized farm;
- Gross Value Added—[GVA_Economy] (million $) (Source: FAO database [35]): total Moldavian Gross Value Added;
- Gross Value Added for Agriculture [GVA_Agriculture] (million $) (Source: Moldavian National Bureau of Statistics [37]): the Gross Value Added of the Moldavian agricultural sector;
- Gross Value Added per Farm [GVA_Farm] ($) (calculated based on 2010 census): the Gross Value Added per farm;
- Gross Value Added per Capita [GVA_Capita] ($) (calculated): the Gross Value Added per Capita;
- Grape Production Value [Grapes_Val] (million $) (Source: FAO database [35]): the total value of Moldavian grape production;
- Maize Production Value [Maize_Val] (million $) (Source: FAO database [35]): the total value of Moldavian maize production;
- Vegetable Production Value [Vegetables_Val] (million $) (Source: FAO database [35]): the total value of Moldavian vegetable production;
- Wheat Production Value [Wheat_Val] (million $) (Source: FAO database [35]): the total value of Moldavian wheat production;
- Grape Production [Grapes_Prod[(tons) (Source: FAO database [35]): the total Moldavian grapes production;
- Maize Production (Maize Prod) (tons) (Source: FAO database [35]): the total Moldavian maize production;
- Vegetable Production [Vegetables_Prod] (tons) (Source: Moldavian National Bureau of Statistics [37]): the total Moldavian vegetable production;
- Wheat Production [Wheat_Prod] (tons) (Source: Moldavian National Bureau of Statistics [37]): the total Moldavian wheat production;

- Total Agricultural Plants Value [TotalPlantsVal] (million $) (Source: Moldavian National Bureau of Statistics [37]): the total value of plants production in the Republic of Moldova;
- Total Agricultural Plants Production [TotalPlantsProd] (tons) (Source: Moldavian National Bureau of Statistics [37]): the total production of plants in the Republic of Moldova

Statistics

Variable	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Subsidies	26.88	2.66	7.98	12.10	20.15	29.10	32.02	37.90
Agr Credit	222.6	26.4	79.1	128.1	167.8	186.4	314.1	342.9
GDP	6765	301	904	5439	5933	6796	7634	7985
GDP Agriculture	1599.2	85.3	256.0	1080.0	1454.6	1634.2	1791.1	1946.6
GDP Capita	1658.9	75.2	225.5	1327.9	1447.7	1673.9	1874.6	1961.5
Farms _No	3718	289	868	2198	3053	3954	4355	4629
Farm Subsidies	7544	1114	3343	5100	5450	7000	7550	16,100
GVA Economy	5722	303	910	4080	4981	5912	6526	6866
GVA_Agriculture	779.8	63.3	189.8	462.2	616.6	817.1	921.8	1041.5
GVA Farm	1032.2	64.2	192.7	777.7	896.8	955.4	1186.7	1381.9
GVA Capita	191.2	15.6	46.9	112.8	150.5	200.5	226.2	255.7
Grapes Val	137.85	8.38	25.13	109.41	114.46	127.73	158.64	179.95
Maize Val	222.0	21.6	64.7	152.0	158.9	216.3	275.3	339.9
Vegetables_Val	5.794	0.461	1.382	3.068	4.979	5.958	7.014	7.598
Wheat Val	126.5	11.8	35.5	63.7	98.5	134.5	151.9	181.2
Grapes Prod	591,778	20,803	62,409	482,000	550,000	599,000	626,000	685,000
Maize_Prod	1,280,489	103,051	309,154	572,000	1,108,928	1,419,193	1,473,413	1,556,230
Vegetables Prod	27322	2443	7328	19028	19924	26302	33116	40542
Wheat Prod	931411	89,257	267,771	495,231	740,410	922,283	1,194,007	1,292,921
TotalPlantsVal	1045.7	66.0	198.1	638.3	953.3	1062.1	1156.8	1355.5
TotalPlantsProd	3,692,889	227,658	682,974	2,177,000	3,398,500	3,881,000	4,170,500	4,523,000

Figure 1. Descriptive statistics of the variables.

Data distribution in relation with the mean and percentiles determines the presence of outliers in the data. Several outliers were identified, like the Farm Subsidies parameter with a value of 16,100.00; GDP Agriculture (1079.98); Total Plants Value (638.32, 1355.50); Grape Production (482,000.00 and 685,000.00, respectively); and Number of Farms (2198.00 and 2357.00, respectively).

4. Results and Discussion: A Custom Analytical Framework for Characterizing the Moldavian Agriculture Sector

The scientific research and literature regarding the Moldavian agricultural system is not extensive. Consequently, we considered it of interest to provide a set of qualitative and quantitative analysis and models that could be used by people and entities to gain a better understanding of the Moldavian agricultural system. Therefore, the proposed framework contains analysis regarding the dynamics of agriculture subsidies and agricultural loans; the dynamics of the agriculture sector GDP and GVA; the dynamics of the agricultural production and production value; and a set of models that would mathematically express the relations found between what we considered as relevant agricultural parameters.

4.1. The Dynamics of Agriculture Subsidies and Agriculture Loans

The agriculture subsidies and agriculture loans are meant to significantly influence the agriculture sector's productivity and sustainability. Therefore, since it is considered a key sector for the Republic of Moldova's economy, agriculture benefits from governmental subsidies are materialized in development of exports, maximization of production and productivity, production diversification in order to introduce new crops with high added value, improving food safety and security and, also, reducing those agricultural regions affected by natural disasters and decreasing the effects of climate change. However, proper policies must be established in order to increase the number of agriculture farms that can access this source of governmental financing. According to Khatkar et al. [38], agricultural credit and subsidies are also considered important supporting factors for agriculture growth. In the Republic of Moldova, the dynamics of agriculture subsidies registered a significant decrease between 2010 and 2011, followed by an upward trend till 2014 (Figure 2). The high number of governmental subsidies recorded in 2013 and 2014 can be most likely associated with the restrictions imposed by the Russian Federation on the Republic of Moldova's agri-food imports and exports. Stratan et al. [39] emphasizes that domestic food producers were mostly exposed to the negative consequences of the Russian restrictive measures in external trade with the Republic of Moldova, during 2013–2014.

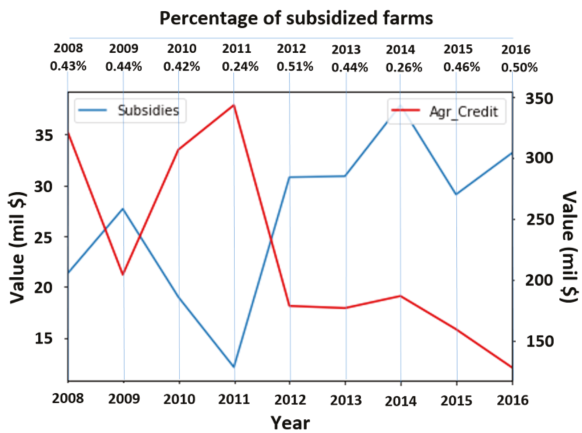


Figure 2. The dynamics of agriculture subsidies, agriculture loans and percentage of subsidized agriculture farms (*the left y axis is associated with subsidies and the right y axis associated with agricultural credits).

However, the percentage of Moldavian agriculture farms that benefit from governmental subsidies is very low, with an average of 0.41% from the total number of registered and active agriculture farms in the Republic of Moldova territory (Figure 2). It also can be observed that the lowest number of subsidy-financed farms is registered both in 2011 and 2014 (Figure 2). For 2011, this result is explained by the low value of available subsidies. For the year 2014, the situation can be justified by the political restrictive measures described above, the fact that created the incertitude related to the possibility of marketing the entire agriculture production and discouraged farm owners to apply for this type of government financial support. The average value of subsidies per agriculture farm during the nine-year period was 7538.46 USD, with the maximum value in year 2014 (16,079.76 USD) and a minimum value in year 2010 (5070.69 USD).

According to the Moldovan Agency for Intervention and Payment in Agriculture (A.I.P.A.) (aipa.gov.md), during the years 2008–2011, the majority of the subsidies' total value (46.40%) were invested in agriculture equipment in order to maximize agricultural mechanization. However, this percentage decreased to 28% between the years 2012 and 2016 (aipa.gov.md).

According to the A.I.P.A., based on the registered data, 19.00% of the total subsidy value allocated by the government were directed by beneficiary agriculture farms, during the period between 2008 and 2011, to post-harvest and processing infrastructure, while this percentage increased to 21.00% between the years 2012 and 2016. The situation is obtained based on the data collected by A.I.P.A. directly from subsidized agricultural farms, related to how the subsidies were spent. The activities set up a multi-annual plantation benefit of 15.00% of the total subsidy value during the years 2008–2011, while during the years 2012–2016 this percentage increased to 17.00%. Furthermore, the production insurance percentage increased from 3.80% of the total value of the subsidies (between 2008 and 2011) to 6.85% (between 2012 and 2016), most likely due to the risks of climate change. Thus, most of the subsidies were used for limiting the possible risks to which agriculture farms are exposed, for developing the irrigation technologies, anti-hail and frost control systems, as well as for on-farm land maintenance investments. Only 3.00% of the agricultural need for financing is covered by subsidies; approximately 33.00% is covered by agricultural loans [37]. The dynamics of the agriculture loans is, in most analyzed years, indirectly correlated with the dynamics of the subsidies. However, there is a large difference between the values of the subsidies and the agriculture loans (Figure 2), a fact that reveals the high demand of Moldavian agriculture farms for financial support. Agricultural long-term loans are mainly used for investment purposes, while short-term loans are for production purposes. Thus, since agriculture loans are more likely accessed by agriculture farms, the farm owners prefer to use these financial founds to cover the facility operational costs and, therefore, maintaining the production potential of the farm. However, if subsidies are accessed, chances for new investments directed for improving fish farms productivity increase. However, most agriculture loans to Moldavian farms are short-term loans. This situation imposes the continuity of the governmental agriculture subsidies program in order to assure the technological development of the agriculture sector. A rational use of both subsidies and agriculture loans can also contribute to the development of a new agricultural production niche, as ecological agriculture.

Thus, if subsidies are invested in order to target the diversification of the production panel with new organic products that resulted from ecological agriculture practices, new consumer market niches can be accessed and exploited, resulting therefore in possible profitability maximization. According to Vozarova and Kotulic [40], agricultural subsidies help to increase the performance and reduce world prices. On the other hand, they also disrupt international markets and reduce economic efficiency.

4.2. The Dynamics of the Agriculture Sector GDP and GVA

The Republic of Moldova's total GDP and GVA dynamics registered an upward trend from 2009 to 2014, with both parameters directly correlated. (Figure 3). As emphasized by Ursu [41] and Valeriu et al. [2], the Moldavian agricultural sector plays a key role in the Moldavian overall economy. He also pointed out that 31.70% of the total Moldavian employment sector worked in agricultural activities, in a context where approximately 2 million people (57.50% of the total population) were living in rural areas.

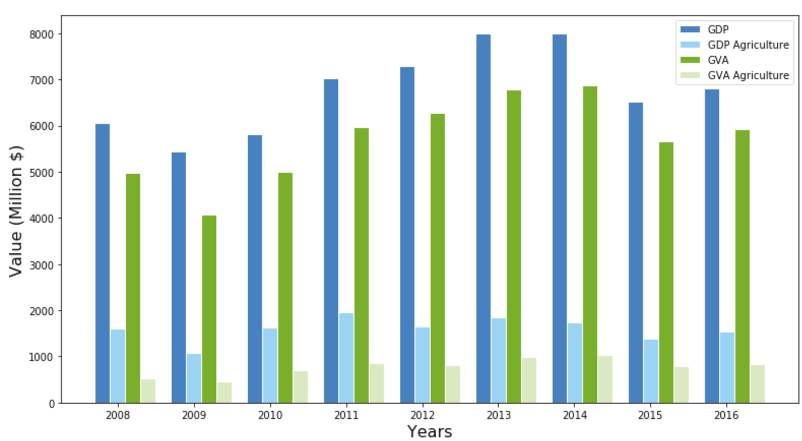


Figure 3. The dynamics of total and agricultural GDP and GVA.

Agricultural GDP makes up to 23.69% ± 2.96% of the Republic of Moldova's total GDP. The highest share of agriculture in relation to total GDP is recorded in 2010 (28.12%), while the year 2009 registered the lowest share (19.85%) of this sector. In the analyzed period (2008–2016), an average 1658.91 ± 255.51 USD for GDP per capita is recorded.

The values of agricultural GDP and GVA correlated with total governmental subsidies show that agricultural product taxes recorded an average value of 846.30 million USD during the analyzed period, with the highest value recorded in the year 2011 (1098.76 mil USD) and the lowest value in 2015 (612.82 mil USD).

The GVA of the agricultural sector makes up 13.46% ± 1.49% of the Republic of Moldova's total GVA. The highest share of agriculture in relation to total GVA was recorded in the year 2014 (15.17%), while 2008 registered the lowest share (10.74%) of this sector. The dynamics of both agricultural GDP and GVA indicators reveals the importance of governmental subsidies in the agriculture sector (Figures 2 and 3), with a major impact between the years 2012 and 2014. The share of the abovementioned indicators in the total GDP and GVA is also significant (Figure 3), a situation which underlines the importance of the agriculture sector for the Moldavian economy.

The agriculture sector can be considered a key sector, with considerable potential to sustain the economic development of the Republic of Moldova. The statement is based both on the agriculture potential of the country (the area of farmland as a share of its total land surface) as well as on the actual share of the agricultural GDP from the total GDP; the average share of the Moldavian GDP from agriculture from the total GDP during the analyzed period was 11.39%, which places the Republic of Moldova in the middle of the Commonwealth of Independent States (CIS), being surpassed by Uzbekistan, Tajikistan, Kirghizstan and Armenia (Figure 4).

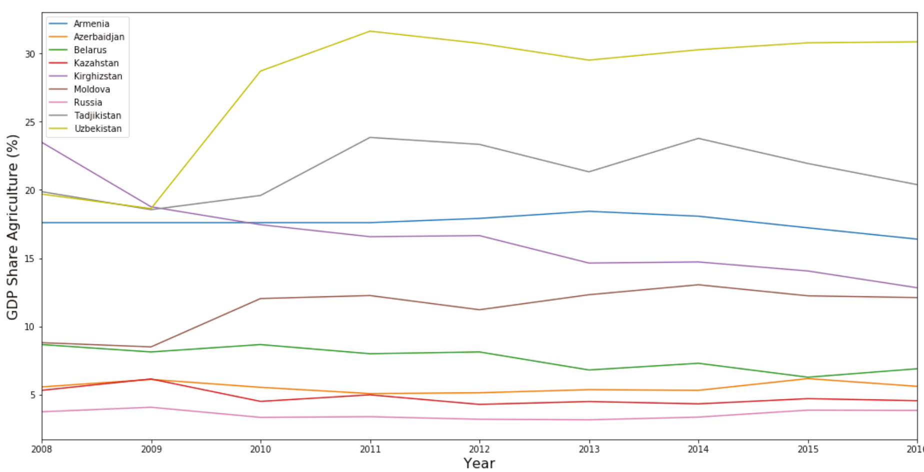


Figure 4. CIS states—the share of GDP from agriculture from the total GDP [34].

However, the first three of the previously mentioned countries have an area of farmland ranging from four to over thirteen times higher than the Republic of Moldova. Thus, it can be stated that, considering the CIS competitors, the Republic of Moldova's economy considerably relies on the agricultural sector's performance.

Still, as shown in Figure 5, in terms of agricultural gross value added, the Republic of Moldova performs poorly, being the last one when compared with the rest of the CIS states.

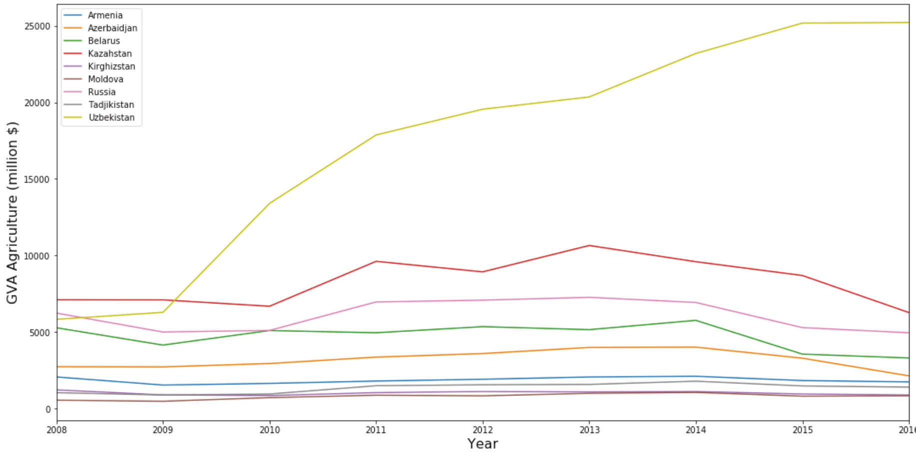


Figure 5. CIS states—GVA for agriculture [34].

4.3. The Dynamics of the Agriculture Production and Production Value

The Republic of Moldova's agriculture production comprises mainly four major crops—maize, grapes, wheat and vegetables. These make up an average share of 76.66% of total the agricultural production recorded during the analyzed period (2008–2016). Maize recorded the highest production of the total production, with an average share of 34.67%, followed by wheat (25.22%), grapes (16.02%) and vegetables (0.74%).

The highest total agricultural production was recorded in the year 2008 (4.52 million tons), while the lowest was in 2012 (2.18 million tons) (Figure 6). Upon observation, the grape production dynamics are relatively constant, while maize, wheat and vegetable production have similar trends (Figure 6). This can emphasize the stability of the grape market. The dynamics of other major crops can also be influenced by the precipitation regime, since the Republic of Moldova does not have a large capacity for functional irrigation systems. According to the FAO [42], the irrigation potential has been estimated at 1.5 million ha, from which around 11% is actually used for agricultural irrigation.

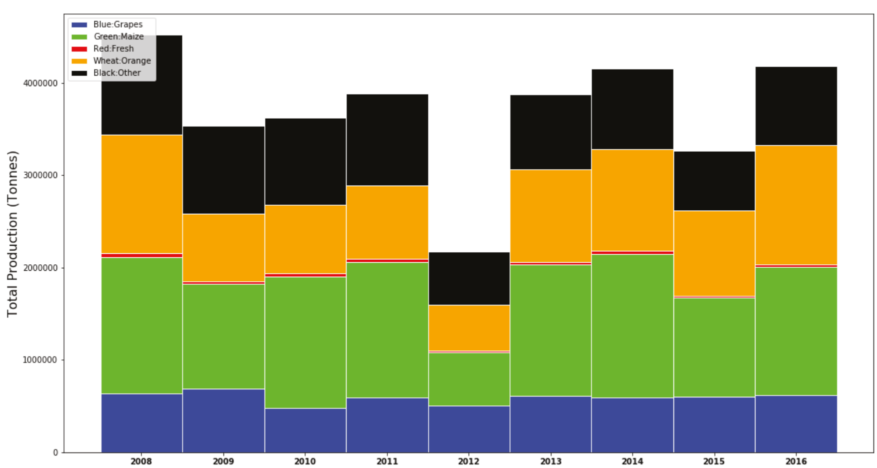


Figure 6. The production quantity of major agricultural crops in the Republic of Moldova.

The growth of agriculture production from 2009 to 2011 can be also attributed to the growth of the national agricultural surface of 34,800 ha [42]. In 2012, the decrease in the national agricultural surface area, due to drought, generated a significant decrease in agriculture production (Figure 6) and, therefore, agricultural production value (Figure 7).

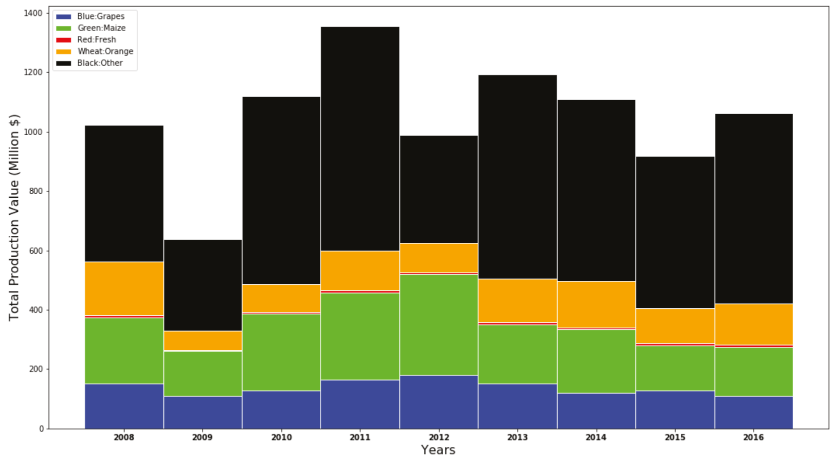


Figure 7. The production value of major crops in Republic of Moldova through agriculture.

The four major crops (maize, grapes, wheat and vegetables) mentioned above contributed an average of 47.06% of the total Republic of Moldova agriculture production value during the analyzed period (2008–2016).

Maize recorded the highest production value of the total production value, with an average share of 21.23%, followed by grapes (13.18%), wheat (12.09%) and vegetables (0.55%).

The highest total agriculture production value was recorded in the year 2011 (1355.5 million USD), while the lowest in 2009 (638.32 million USD) (Figure 7). It can be observed that the evolution of the production value in this year (Figure 7) is directly correlated with the agricultural loan dynamics (Figure 2). It can be observed that the agriculture production value dynamics (Figure 7) are significantly influenced by market supply-and-demand, as it differs from the agricultural production dynamics (Figure 6). The dynamics recorded between 2012 and 2014 can be also associated with the restrictions imposed by the Russian Federation on the Republic of Moldova's agri-food imports and exports.

The decrease in production and production value registered in 2009 and 2012 can be also explained by the decrease in foreign direct investments in the Moldovan agriculture sector. Thus, the foreign investments in Moldovan agriculture registered a share of 1.51% from the total investment values in the year 2009; this was 2.62% in 2011 compared to 2.85% in 2012 [43]. Furthermore, according to Șargo [17], the number of employees in the agriculture sector in 2012 was reduced by 60.6% compared to the year 2000 (770,000 employees), and by 4.5% compared to 2011. Exceptionally, for 2014, the EU also decided to double the export quotas without custom duties for grapes (from 10 to 20 thousand tons). Despite the embargo imposed by the Russian Federation on Moldovan agricultural products, exports of agri-food products increased by 12% in 2013 compared to 2012, and exports of agri-food products to the EU increased by 22% compared to the same period of 2013 [38]. Șargo [17] highlights that the lack of both agricultural post-harvest infrastructure and low to none cooperation between agricultural producers in the export process are major obstacles in maintaining the quota on traditional markets and expanding exports to potential new markets. Both the awareness of market requirements and the ability to make strategic decisions to meet those requirements are decisive for the development of agriculture. Furthermore, investments in equipment and in quality-enhancing infrastructure (especially greenhouses for vegetables) to strengthen the production capacity, to promote private investment as well as to build sector resilience to adverse weather events (stimulating investments in anti-hail nets, anti-frost systems, on-farm irrigation structures, etc.), can be considered key points regarding the need for investment in the Moldavian agriculture sector.

4.4. The Correlation Matrix

In our research, we used a correlation matrix as a tool to summarize the linear relations existent in our data and for identifying the strong and relevant relations that could be further modelled. Therefore, as part of the analytical framework, all data related to the main indicators that characterize the Moldavian agriculture sector were processed using the Python Seaborn library for obtaining a correlation matrix (Figure 8).

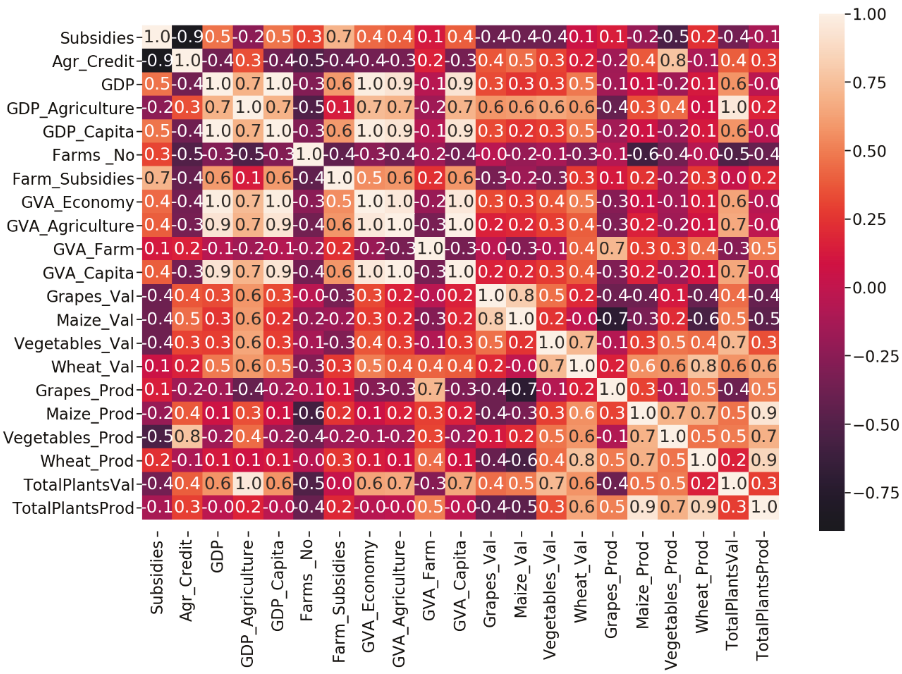


Figure 8. Correlation matrix of main indicators that characterize the Moldavian agriculture sector.

By analyzing the correlation matrix, significant direct correlations are found between vegetable, maize and wheat production and production values and total agricultural production, respectively (Figure 8). Therefore, the economic indicators associated to these three major crops (maize, wheat and vegetables) can be used as tools in order to control and maximize the productivity of the agriculture sector.

The dependence of the Moldavian economy on its agriculture sector is revealed by the significant direct correlations between the total agricultural production value and total GVA, the agricultural GVA and the agricultural GDP (Figure 8). However, maize and vegetable production values present strong direct correlations with agricultural GDP (Figure 8).

Direct, strong correlations in terms of production are also observed between vegetables, maize and wheat (Figure 8). Grapes also can be correlated directly, in terms of production value with maize (Figure 8). The positive effect of agriculture loans is revealed by the direct correlation of this indicator with total agricultural production (Figure 8). In terms of significant negative correlations, the strongest was recorded between the value of agriculture subsidies and agriculture loans, depicting the fact that when the agricultural subsidy value is increasing, the agricultural loan value decreases. (Figure 8). Starting from the correlation matrix that displayed the possible parameter relations, we further investigated which relations could be actually formalized through linear or non-linear models through curve-fitting and model detection techniques.

The following part will present several investigated cases, providing a parametric model and the residual plots for assessing whether the observed error (residuals) is consistent with the stochastic error (Appendix A). It also should be mentioned that due to the limited number of samples, as yearly data is analyzed, multiple regression could not be performed, as a minimum of 10 samples should be available for each of the predictors—see Austin and Steyerberg [44]. Model residuals plots should emphasize that it is not possible to predict the error for any given observation, having the residuals consistent with the random error. Residuals should be centered on zero throughout the range of fitted values.

More than that, while using an OLS approach, random errors are assumed to produce residuals that are normally distributed. Therefore, the residuals that should not be correlated with another variable or to each other (if adjacent) should fall in a symmetrical pattern and have a constant spread throughout the range. If there is a non-random pattern in the residuals, this would indicate the deterministic portion (predictor variables) of the model is not capturing some explanatory information that is transferred into the residuals.

For each scenario, several models were tested and those considered more relevant were presented. For identifying how well the models fitted the data, metrics like S (the standard error of the regression), R-squared and adjusted R-squared were used. The standard error of the regression provides the absolute measure of the typical distance that the data points fall from the regression line (Appendix A). The S value represents a number using the same unit as the dependent variable. Normally, smaller values are better as they indicate that the observations are closer to the fitted line.

4.5. Models Based on Main Crops Production

Both wheat and maize production proves to significantly influence the total Moldavian agriculture production. The model representing the relation between wheat production and total plant production (Figure 9) has a high R-square. The residuals display a normal distribution (Figure A1), being independent from one another. As the value of the wheat production increases, the value of total plant production increases (one unit of wheat production leading to a 2.17 unit increase in total plants production). The relation between maize production and total plant production is strongly linear (Figure 10), showing an R-square of 88.00%, higher than the one found when modelling wheat production–total plant production. The residuals also display a normal distribution, being independent from one another (Figure A3). As maize production value increases, the value of total plant production increases (one unit of maize production leading to a 2.07 unit increase in total plant production). The models can be used in order to assess the total agriculture production indicators by variating both the maize and wheat production quantity.

Therefore, in order to grow the agricultural production, the maize and wheat production capacity must be maximized. Thus, it is recommended that a significant share of government financial resources be used in order to develop and implement better growth technologies for these crops, as well as to implement proper technical measurement for maintaining the optimum technological requirement of them during the entire year’s production cycle.

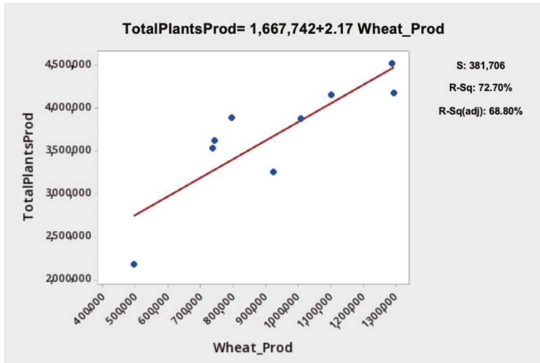


Figure 9. Wheat production–total plants production.

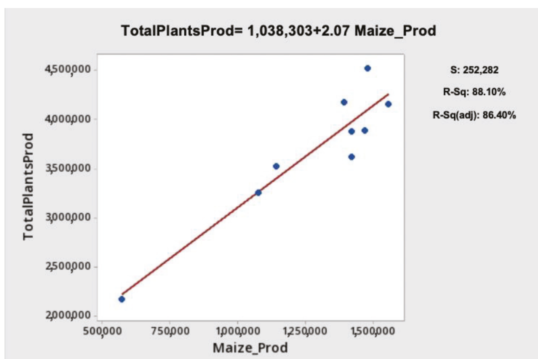


Figure 10. Maize production–total plants production.

4.6. Models Based on Main Crops Production Value

Wheat production–wheat production value follows a linear positive trend (Figure 11). The model describes this while having the regression *p*-value at 0.01, an R-square of 60% and independence of the residuals. This, according to the histogram and normal probability plot (Figures A5 and A6) are right skewed (working with a low number of samples usually has an effect over the residuals histograms as a histogram is most effective when there are 20 or more data points. If the sample is too small, then each bar on the histogram does not contain enough data points to reliably show skewness or outliers). This model emphasizes the stability and high liquidity of the wheat market. Therefore, the wheat market is characterized by high trading activity and high wheat supply and demand. Thus, Moldavian wheat production will sell fast, without any constrains related to price, in order to make this crop production more attractive for buyers. The grape production value–maize production value scenario is characterized by no variation and no correlation of the residuals (Figure A7). The model explains 65% of the maize production value variance by using the grape production value (Figure 12). The *p*-value for the grape production value is 0.008, below the 0.05 threshold (Figure A8). The equation shows that for every unit increase in the grape production value, the maize production value will increase with 2.09 units. Thus, the model emphasizes the complementarity between both the grape and maize markets in terms of the prices established for both crops during the analyzed nine-year period.

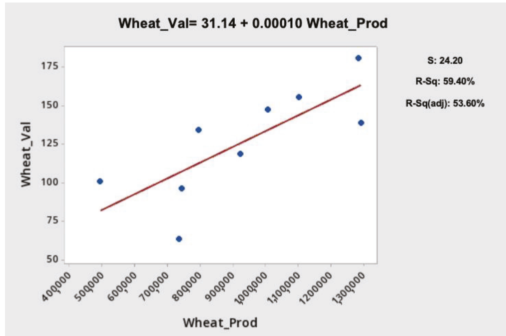


Figure 11. Wheat production–wheat value.

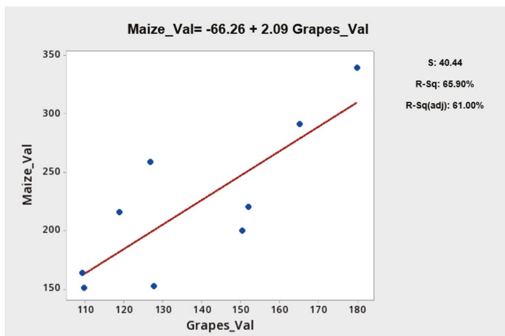


Figure 12. Grape value–maize value.

4.7. Models Based on Crops Production Value vs. GVA and GDP Economic Indicators

As expected, the R-square value of the model depicting the relation between the agricultural production value and agriculture sector GDP is very high at 92.70 (Figure 13). The adjusted R-square is similarly large, the residuals displaying a constant variance and independence (Figure A9). This emphasizes that the agriculture sector's GDP is mostly influenced by the agriculture production value and less influenced by taxes. This facilitates the control of size and growth rate of agriculture economy.

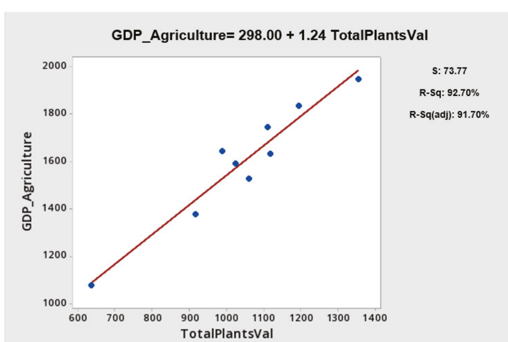
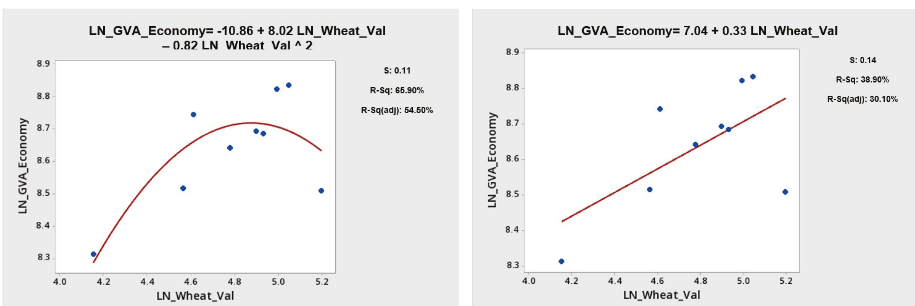


Figure 13. TotalPlantsVal–GDP_Agriculture.

At first glance, as represented in the table fitted line plot, the relation between the wheat production value and total GVA is linear (Figure 14). Still, due to a special case, in which for a high wheat production value there was a low total GVA, the linear model fails to perform very well. The regression *p*-value is 0.07 (Figure A12), close to the 0.05 significance level, but according to the R-square the model is explaining 38.00% of the variance. The quadratic model fits the model much better. Still, future observations are required in order to more clearly asses the overall context (Figure 14a). The model emphasizes the important share of wheat production value from the total GVA of the Republic of Moldova. Therefore, the wheat market has a significant impact on all of the Moldavian economy and can be used as an instrument of macro-economic control. The total agriculture plant production value–agriculture GVA displays a positive linear trend and the linear model can explain around 43.00% of the agricultural GVA based on the total plants value (Figure 15). The regression *p*-value is 0.05 (Figure A14), while the residuals displays almost constant variance, independence and a good normal probability plot (Figure A13). This model confirms the transparency between total production value and GVA in the agriculture sector.



(**a**) (**b**)

Figure 14. (**a**) Wheat Value–GVA economy quadratic. (**b**) Wheat value–GVA economy.

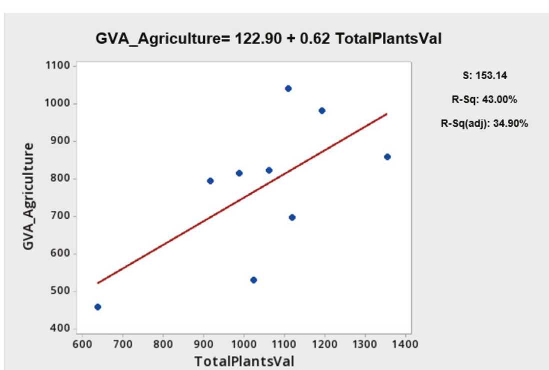


Figure 15. TotalPlantsVal–GVA_Agriculture.

4.8. Models Based on GVA and GDP Economic Indicators

The relation between agriculture GVA and total GVA is strongly linear (Figure 16); the model shows independent normally distributed residuals, with constant variance, a high 91.80 R-square, a very low S-value at 0.05 and a regression *p*-value at 0 (Figures A15 and A16). As such we can determine the value for total GVA relying on agriculture GVA. As we used natural logarithms for the terms of the model, a 1.00% increase of the agriculture GVA will lead to a 0.59% increase of total

GVA. This model emphasizes the importance of agriculture sector for the Republic of Moldova's economy, as this sector can be used as a control tool to induce long term economic development.

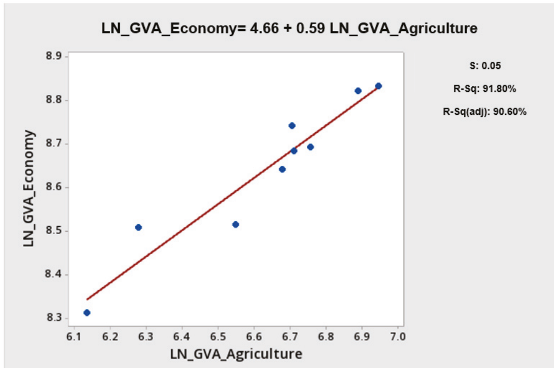


Figure 16. GVA_Agriculture–GVA_Economy.

As noticed in the Figure 17, the relation between GDP (as predictor) and agricultural GVA (as explained variable) can be linearly expressed, having for residuals a slightly visible variation and no correlation (Figure A17). As for the equation coefficients, they are showing that for a 1% increase in agricultural GVA, the GDP value will increase by 0.45%. This model completes the previous model, thereby emphasizing the importance of the agriculture sector in the Moldavian macro-economy.

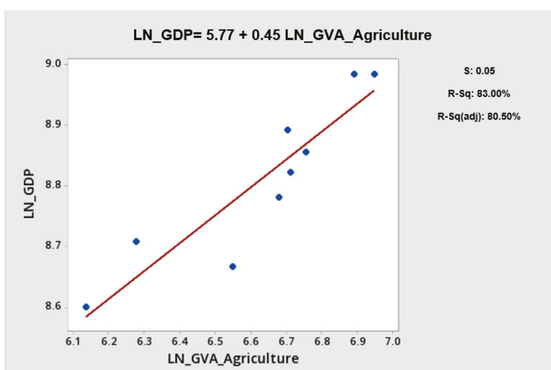


Figure 17. GVA_Agriculture–GDP.

4.9. Models Based on Agriculture Subsidies and Agriculture Loans

The model presented in Figure 18 describes the relation between the agricultural credit and vegetables production with a regression p-value at 0.01 (Figure A20). Thus, this reveals that a significant part of agriculture loans is used for vegetable production. Therefore, agriculture loans can be used as control tools for maximizing the vegetable production.

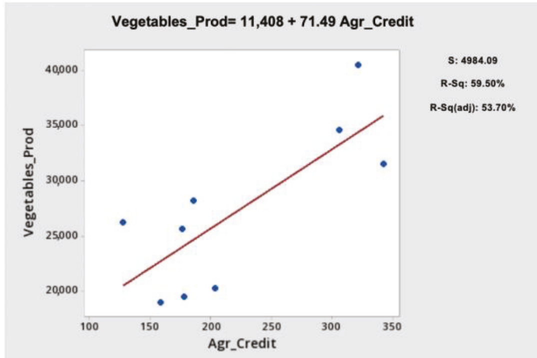
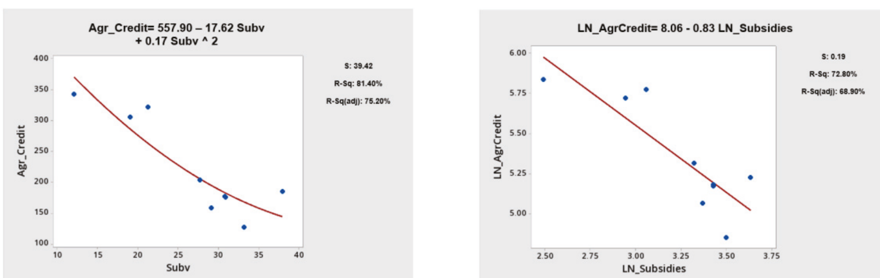


Figure 18. Agr_Credit. – Vegetable_Prod model.

An important model describes the relation between governmental agriculture subsidies as predictor and agricultural loans (Figure 19a). With a maximum R-square of 81.40, governmental agriculture subventions explain the variability in agricultural loans.

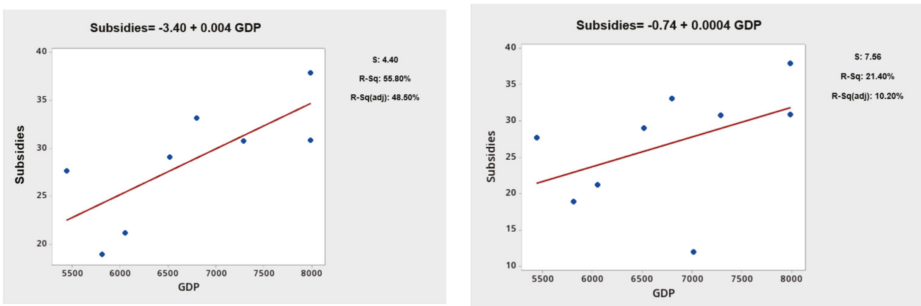


(**a**) (**b**)

Figure 19. (**a**) Subsidies–Agr_Credit quadratic model. (**b**) subsidies–Agr_Credit model.

The Versus Order chart shows no particular form of dependence of the error terms, while the distribution of the residuals, according to the normal probability plot, is normal (Figure A21). By using a linear approach for the same scenario presented in Figure 19a, a lower R-square is obtained, respectively 72.80% (Figure 19). Still, as the model involves a linear equation, it is easier to numerically grasp the relation between the predictor and the dependent variable. The equation shows that for every extra 1% additional subsidies, the agricultural credit will decrease by an average of 0.83 percent. However, this negative correlation between agriculture subventions as predictor and agricultural loans is expected as they must work as complementary financing sources. In this direction, it is recommended to cover the gap between the value of governmental agriculture subsidies versus the value of agricultural loans.

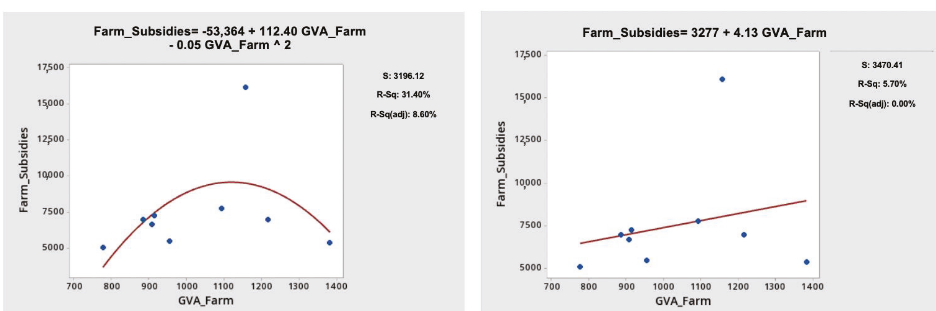
At first glance it seems there is linear relation between total GDP and subsidies (Figure 20). Still, due to a situation in which for the medium-high total GDP value there was a very low subsidy value, the model returned an R-square of only 21.40%. Removing that data point would generate the following situation: both the R-square and adjusted R-square significantly increased, and as the equation shows, for every 1 unit GDP increase the subventions will increase with 0.004 (Figure 20a). Still, we consider the R-square to be quite low for some conclusions to be drawn. However, by analyzing Figure 20a, after the outlier removal, the total GDP–Subsidy model returned an R-square of 55.80%. However, it is hard to identify a certain pattern between total GDP and subsidies value since the percentage of subsidized farms was less than 1%. It is possible that if the subsidies values rise the effect of this governmental financial support will be better observed in the Republic of Moldova macro-economy and, therefore, in the total GDP.



(**a**) (**b**)

Figure 20. (**a**) GDP–Subsidies—outlier removed. (**b**) GDP–Subsidies model.

The conclusions mentioned at the previous described model (between total GDP and governmental agriculture subsidies) are confirmed by the model from Figure 21 which describes the relation between GVA per farm and subsidies per farm and that displays some peculiarities. Even if it is not statistically relevant, with an R-square of 31.40%, it is still possible to see why the value is low (Figure 21a,b). This is mainly due to a specific case where, for a very high value of subsidies per farm (16,100 USD) in 2014, the GVA per farm was not as high as expected, probably due to external factors. Another peculiar fact is that high values of GVA per farm are associated with low values for subsidies per farm.



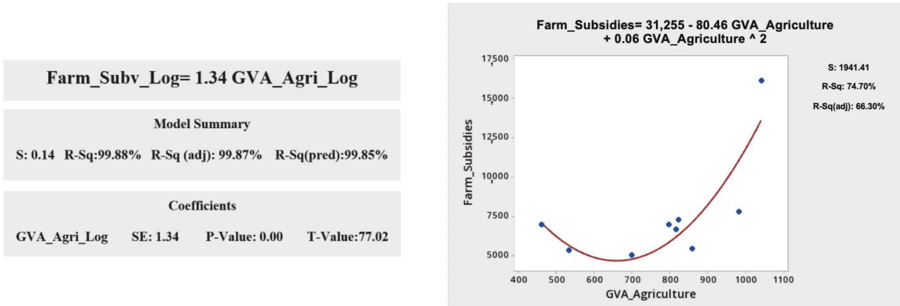
(**a**) (**b**)

Figure 21. (**a**) GVA_Farm–Farm_Subsidies quadratic. (**b**) GVA_Farm–Farm_Subsidies.

Actually, subsidies per farm does not change much, while GVA per farm almost doubles, so it seems that directly, subsidies per farm does not radically influence the GVA per farm. This can be due to the direction in which subsidies are invested by farm owners.

As mentioned previously, subsidies are mainly directed toward technical investments and not to yearly production; therefore, their effect may be visible on a long-term period and during the years in which the climate change effect is more intense.

An increased agricultural GVA is associated with a constant increase in the subsidies per farm (Figure 22). The data presents an outlier, where for a small increase in agricultural GVA there was a significant increase of subsidies per farm, probably due to external factors that were not considered. Still, the best model is obtained when we apply the log function to both predictor and dependent variable, having an R-square of 99.88 (Subsidies per farm Log = Log (Subsidies per farm) and Agriculture GVA Log = Log Agriculture GVA) (Figure 22a).



(**a**) (**b**)

Figure 22. (**a**) GVA_Agriculture–Farm_Subsidies Log. (**b**) GVA_Agriculture–Farm_Subsidies.

The Figure 23 displays how subsidies influence subsidies per farm. As it can be noticed, subsidies per farm mostly increase with the increase of subsidies. The quadratic are better representations of the current situation due to the high value subsidies per farm point, which is also associated with the highest value for subsidies. The S value, at 1502, can be considered small for a scale ranging from 2000 to 16,000. Both the agricultural GVA–subsidies per farm model and subsidies–subsidies per farm model where possible in conditions of a relatively constant dynamics of agriculture farm number. However, their significance is expected to decrease in a long-term macro-economic analysis, when agricultural farm number can register higher variations.

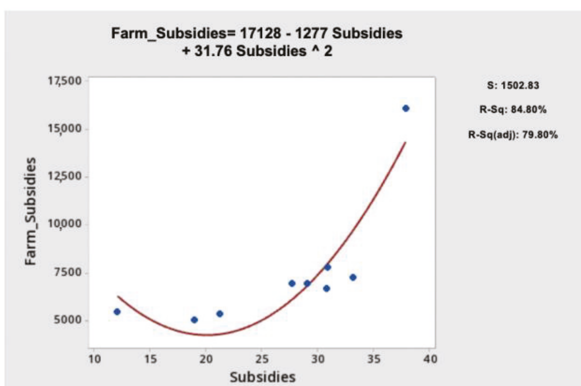


Figure 23. Subsidies–Farm_Subsidies model.

All models described above will contribute to a better understanding of the Moldavian agriculture sector, offering tools that can be used in order to ensure an efficient intervention that targets to maximize the performances of this sector in different scenarios and, therefore, contribute to the economic sustainability of agriculture sector.

As with the majority of studies, the design of the current study is subject to limitations. One limitation of the present paper's analytical framework is the lack of a multifactorial connection between the economic subsystem and social and environmental subsystems. This would potentially establish a better agriculture sustainability approach. However, the economic sustainability of agricultural activities is considered the basic constraint for the survival of farm systems over time [45]. Therefore, if agriculture sustainability is targeted, economic sustainability must be the starting point.

The second limitation concerns the economic indicators list that could be extended in order to elaborate on a more complex analytical framework. According to Latruffe et al. [46], a wider range of indicators has been proposed to capture various economic properties of farming systems that are associated with sustainability, such as profitability, liquidity and stability or autonomy/dependence [47]. However, subsidy-dependence can be considered an aspect of autonomy: if farms are highly dependent on public support, any policy reform that reduces subsidies could put farm sustainability at risk [46]. Other studies [48] that multidimensionally analyzed agricultural economic sustainability used specific indicators that analyse the imports and exports of agricultural products, as well as the gross regional product values compiled with the crop productivity indicators.

The analysis of agricultural economic sustainability can be oriented towards different types of fish farms according to their production potential. Therefore, studies which assessed the sustainable economic development for family farms [49] developed the analytical framework based on indicators such as return on equity, return on assets, operating expense, debt to assets, debt to total output, depreciation expense or gross margin.

The economic dimension of agricultural sustainability is characterized in other studies by using various economic and socio-economic indicators [50–54]. However, the evaluation of the economic sustainability of farms involves a wide range of sustainability themes that are difficult to combine in a unique approach [50,51]. Therefore, by using a multifactorial approach that considers labor, land profitability and productivity, as well as vitality marginalization, diversification of farmer labor, competitiveness, incidence of agricultural value added and fixed investment in agriculture, Dillon et al. 2014 [53] concludes that efficient agricultural structures, appropriate technologies as well as the diversification of income sources for farms are critical elements for the achievement of the agricultural sector's economic sustainability. Other studies [50,54] concluded that the diversification of farm activities significantly contributes to the economic sustainability of agriculture, while using an analytical framework structured on the following indicators: value of production, value added, farm ability to generate income, autonomy, diversification of the production, business diversification and multifunctionality.

The third limitation of the present study concerns the lack of governance and institutional capacities indicators. This is because governance is an essential driver of both agricultural productivity and sustainability in developing countries [55]. However, those indicators are related to agricultural policies and technological interventions that would rather concern the political economy approach, although correlating the two sustainability subsystems (economic and political subsystems) could raise the analytical framework level of complexity.

However, analytical framework studies that are predominantly based on economic and production indicators revealed that the effect of agricultural GDP growth on poverty reduction is at least twice as high as the effect of GDP growth coming from other sectors.

For the Republic of Moldova's agriculture, analytical framework studies were conducted in order to increase the competitiveness of the horticultural sector [56]. This revealed that with the increase of the share of the horticultural production sales income regarding the total sales income, being more than 20%, the enterprises will be more competitive on the market, registering higher values of total productivity factors. Furthermore, a study [56] confirmed that horticulture may represent a solution for developing the Moldavian agriculture sector. This is due to the fact that the agriculture farms that had a share of the horticultural production sales income in total sales income of more than 20% performed better in terms of financial productivity.

However, no similar studies concerning the economic sustainability of the Republic of Moldova's agriculture sector were found in the literature.

The present study confirms that agriculture subsidies and agriculture loans can be also used directly in order to raise the share of agriculture GDP in total GDP. However, Lopez et al. [57] in their study related to agriculture subsidies in China has issued a hypothesis according to which the larger the share of agriculture is in the economy, the costlier it will be to subsidize; also, in the long term, subsidy governmental programs may cause farm dependence [46] and if stopped or reduced, may cause significant economic disturbances. In the present study, an indirect correlation is observed between governmental agriculture subsidies value and agriculture loans. In spite of this correlation, the value of subsidies is considerably low compared to agriculture loans and only a small percentage of total agriculture farms managed to access them during the analyzed years. Thus, agriculture governmental subsidies cannot be considered financial sources for the substitution of agriculture loans. However, the relation between agriculture loans and subsidies presented in present study can be attributed to the fact that, in general, subsidy financing programs are a result of governmental policy intention of supporting the agricultural economic sector during a certain period of time. Therefore, the high level of governmental subsidies is proportional with other measures, both being part of governmental support programs which targets to improve the economic sustainability of agriculture sector. Therefore, the dynamics and size of subsidies can emphasize the intensity of governmental supporting program of which they belong rather than its real financial value. This hypothesis can also explain the direct correlation between the value of farm subsidies and agriculture GVA. Thus, if the subsidies' size and dynamics reveal the intensity of then governmental supporting program, this must be observed on the agricultural GVA dynamics. However, the relationship between the agriculture sector's performance and governmental supporting programs intensity can be inverse [58] if inconsistent financing policy is applied over long periods—the increase of financial support must be applied before a relative downsizing of the agriculture sector. Recent studies [59] have revealed the positive effect of subsidies in modern maize agriculture, only if this financial support is invested in crop-growing technology, specifically in seeds and fertilizers. Therefore, Vozarova and Kotulic [40] concluded that removal of agricultural subsidies would contribute to increasing the income disparities between rural and urban areas, which would lead to an exit of domestic farmers from the industry. For this reason, according to Won and Kennedy [60] most countries use some form of subsidy in order to protect their agriculture, since studies [61] have been proven it to be the most effective mechanism for accelerating the growth of the agricultural sector. However, although several studies proved the effects of subsidies and other financial tools on productivity [62–64] or the efficiency of agriculture [65–69], the subject still remains open for discussion, as it depends on numerous series of climate, social or political variables.

In present study, the significantly high correlation between total GVA and agricultural GVA reveals the significant influence of the agriculture sector in assuring and improving the Republic of Moldova's economic performance. This confirms the findings of Timofti et al. [3], who emphasized that the financing and developing of the Moldavian agriculture sector is a cornerstone in achieving modernization; also, Dinu et al. [19] encourage the development of the agriculture sector since it has great importance for the economic growth of the Republic of Moldova. A country that is not self-sufficient in food production can be more vulnerable to commercial pressure and the global food crisis [70].

The direct correlations between agricultural loans and vegetable production can be due to the peculiarities of vegetables production systems. Therefore, most of the vegetable production is obtained in greenhouse, intensive crop production systems, since the seasonality of these crops can significantly influence their profitability [6]. Thus, the influence of the agricultural loan value on vegetable production can be justified because the production intensity of greenhouse-based systems is significantly dependent on the level of financial investment in high-performance equipment, which assures a maximization of growth performance and a good seasonality compared to the competitors from other countries.

The present study also emphasizes the importance of Moldavian wheat production for the economic growth. Therefore, a direct correlation was identified between wheat production value and total GVA. Wheat and maize production quantity is also strongly and directly correlated with total plant production, revealing the importance of the production performance of these two crops for the Moldavian agriculture sector. Thus, the policy of supporting the improvement of production technologies for maize and wheat in order to maximize their growth rate can raise the economic sustainability of the agriculture sector.

Although advanced data analysis frameworks are performed, it is hard to establish a general model that will perform perfectly in all circumstances. This was also confirmed by Nowak et al. [71], who argue that to evaluate the performance and effectiveness of agriculture is quite complicated, not least due to the instability of the climatic conditions but also due to the wide variety of households in view of their economic strength and production profile.

5. Conclusions

The agriculture sector has a major impact on the Moldavian economy, a fact revealed by the significant model between agricultural GVA and total GVA. The Republic of Moldova's agriculture policies must focus on maintaining a high and constant financial standard for governmental agriculture supporting program, in order to improve the economic sustainability of this production sector. However, a negative significant correlation was identified between agriculture subsidies supporting programs and agriculture loans. Therefore, it is recommended to assure the complementarity of the two funding sources (agriculture supporting programs and agriculture loans), in order to obtain a better economic performance of the agriculture sector.

The supporting programs prove to be highly efficient for increasing the production quantity of crops cultivated in greenhouse, intensive production systems, such as vegetables. Thus, since vegetable production has both a social and economic impact (improving the living standards of rural communities and increasing the agri-food exports) it is recommended to continue and even increase the governmental agriculture supporting programs for maximizing the production of these crops.

The Moldavian agriculture sector recovered its production potential after the drop registered in the year 2012 caused by drought and after the restrictions imposed by the Russian Federation on Republic of Moldova agri-food imports and exports, between the years 2013–2014. The direct significant correlation model between the wheat and maize production and total agriculture production reveals the importance of these crops to the Moldavian economy. It is recommended to focus the governmental financial support on improving the technologies that lead to a superior productivity of these crops in order to improve the economic sustainability of the Moldavian agriculture sector.

Future avenues of research should target the improvement of the present analytical framework by expanding the current dataset with other indicators, describing the existing relations between the economic, social and environmental systems so it could be used as an efficient tool for identifying better agricultural sustainable strategies. As such, since the complexity of the analytical framework is positively influenced by the number of analyzed parameters and the dataset size, other relevant economic indicators like liquidity, stability, autonomy/dependence, return on equity, return on assets, operating expense, debt to assets, debt to total output, depreciation expense, gross margin, farm ability to generate income, diversification of the production and, also, business multi-functionality, are recommended to be added in the analysis.

Moreover, the Republic of Moldova's governance and institutional capacities can provide relevant parameters in enhancing the agriculture sector's analytical framework, so the political system could be also linked to the economic, social and environmental systems. Lastly, as more data would be available, several other modelling techniques could be used. For example, future studies could consider multiple linear regressions enhanced by using lasso, ridge or elastic net regularization methods; support vector regressions; or an extended array of ensemble learning prediction methods like Ada Boost, Gradient Boosting, XGBoost, Bagging, GBM and CatBoost.

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literature review and drafting of the manuscript. All authors have read and agreed to the published version of the manuscript

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A Models Residual Plots and Analysis of Variance

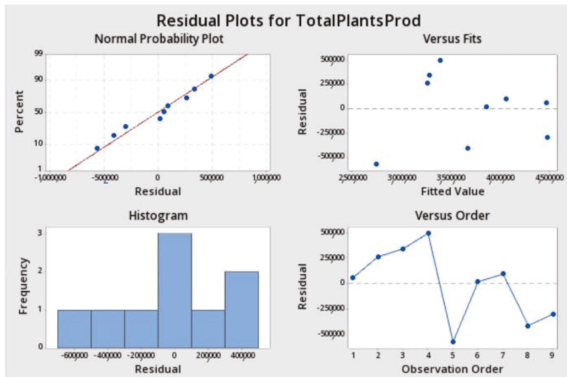

Figure A1. Wheat Prod–Total Plants Prod residuals.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	2.71*10^12	2.71*10^12	18.61	0.004
Wheat_Prod	1	2.71*10^12	2.71*10^12	18.61	0.004
Error	7	1.02*10^12	1.46*10^11		
Total	8	3.73*10^12			

Figure A2. ANOVA Wheat Prod–Total Plants Production.

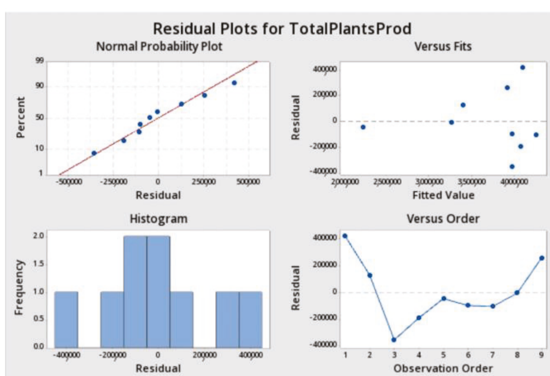

Figure A3. Maize–Total Plants Prod.

Source	DF	SS	MS	F	P
Regression	1	3.29*10^12	3.29*10^12	51.63	0.00
Error	7	4.46*10^11	6.36*10^10		
Total	8	3.73*10^12			

Figure A4. ANOVA Maize–Total Plants Prod.

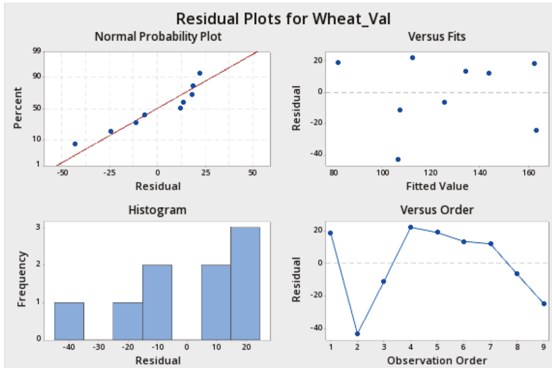

Figure A5. Wheat Prod–Wheat Value.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	6010	6009.9	10.26	0.01
Wheat_Prod	1	6010	6009.9	10.26	0.01
Error	7	4100	585.8		
Total	8	10,110			

Figure A6. ANOVA Wheat Prod.–Wheat Value.

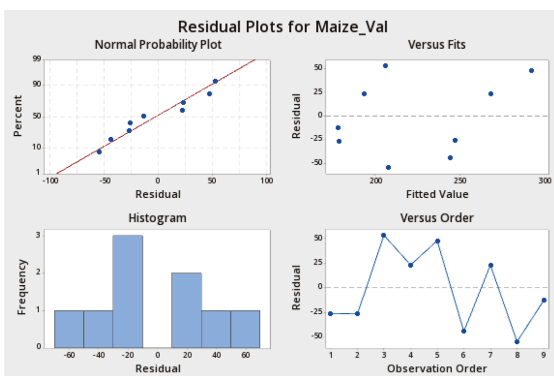

Figure A7. Grapes Value–Maize Value.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	22,089	22,089	13.50	0.008
Grapes_Val	1	22,089	22,089	13.50	0.008
Error	7	11,450	1636		
Total	8	33,539			

Figure A8. ANOVA Grapes Value–Maize Value model.

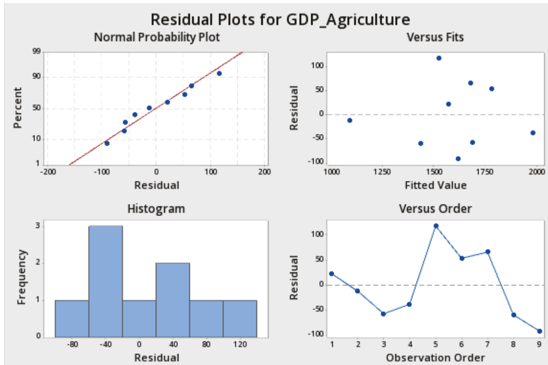

Figure A9. TotalPlantsVal–GDP_Agriculture.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	486,104	486,104	89.32	0.000
TotalPlantsVal	1	486,104	486,104	89.32	0.000
Error	7	38,095	5442		
Total	8	524,198			

Figure A10. TotalPlantsVal–GDP_Agriculture.

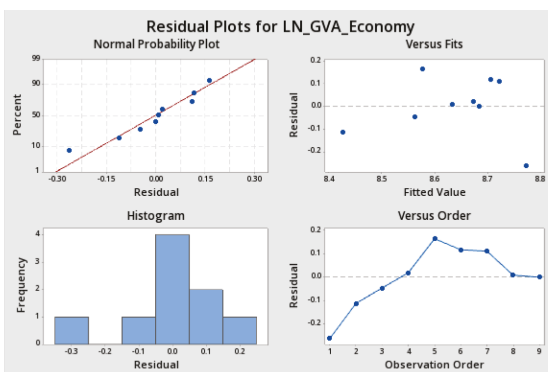

Figure A11. Wheat Value–GVA_Economy.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	0.09	0.09	4.45	0.07
LN_Wheat_Val	1	0.09	0.09	4.45	0.07
Error	7	0.14	0.02		
Total	8	0.23			

Figure A12. ANOVA Wheat Value–GVA_Economy.

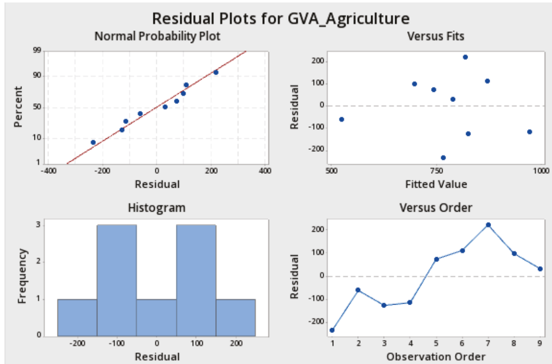

Figure A13. TotalPlantsVal–GVA_Agriculture.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	123,883	123,883	5.28	0.05
TotalPlantsVal	1	123,883	123,883	5.28	0.05
Error	7	164,176	23,454		
Total	8	288,058			

Figure A14. ANOVA TotalPlantsVal–GVA_Agriculture.

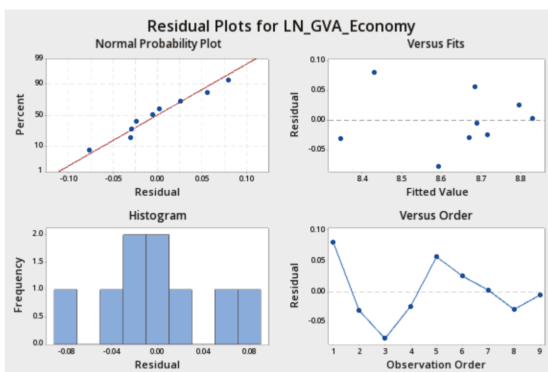

Figure A15. GVA_Agriculture.–GVA_Economy.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	0.21	0.21	78.49	0.00
LN_GVA_Agriculture	1	0.21	0.21	78.49	0.00
Error	7	0.02	0.00		
Total	8	0.23			

Figure A16. ANOVA GVA_Agriculture–GVA_Economy.

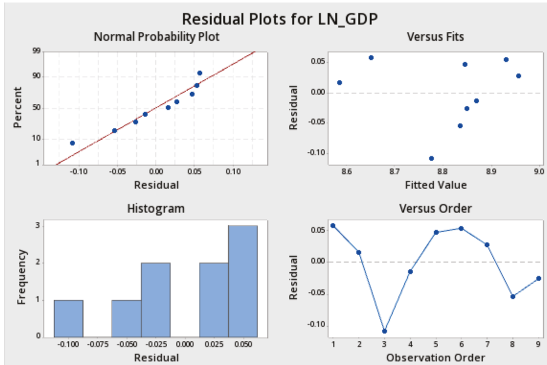

Figure A17. GVA_Agriculture–GDP.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	0.12	0.12	34.07	0.001
LN_GVA_Agriculture	1	0.12	0.12	34.07	0.001
Error	7	0.02	0.00		
Total	8	0.15			

Figure A18. ANOVA GVA_Agriculture–GDP.

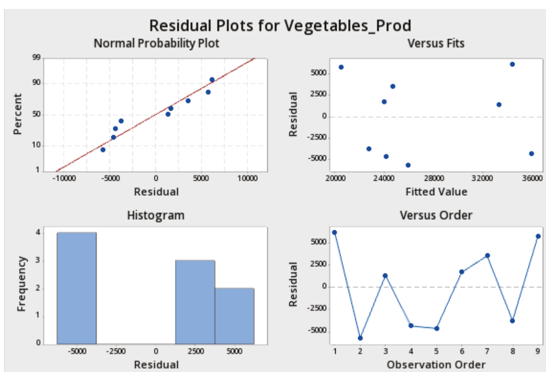

Figure A19. Agr_Credit–Vegetable_Prod.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	255,742,064	255,742,064	10.30	0.01
Agr_Credit	1	255,742,064	255,742,064	10.30	0.01
Error	7	173,888,152	24,841,165		
Total	8	429,630,216			

Figure A20. ANOVA Agr_Credit. – Vegetable_Prod.

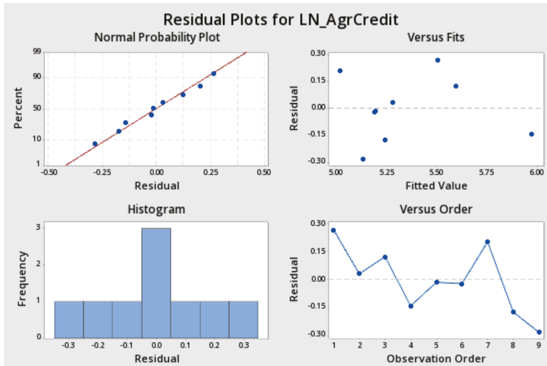

Figure A21. Subsidies–Agr_Credit.

Source	DF	SS	MS	F	P
Regression	1	0.69	0.69	18.73	0.003
Error	7	0.26	0.03		
Total	8	0.95			

Figure A22. ANOVA Subsidies–Agr_Credit.

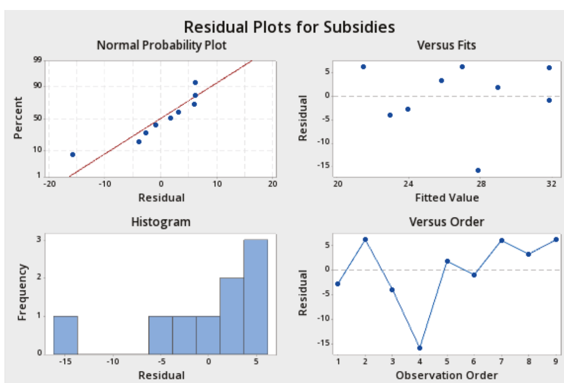

Figure A23. GDP–Subsidies model residuals.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	109.10	109.06	1.91	0.21
GDP	1	109.10	109.06	1.91	0.21
Error	7	400.50	57.22		
Total	8	509.60			

Figure A24. ANOVA GDP–Subsidies.

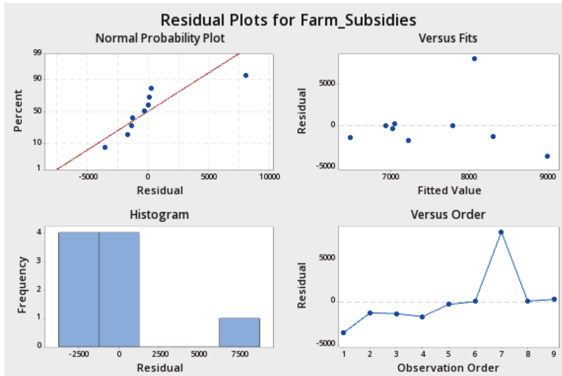

Figure A25. Farm_Subsidies - GVA_Farm.

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	1	5,075,840	5,075,840	0.42	0.537
GVA_Farm	1	5,075,840	5,075,840	0.42	0.537
Error	7	84,306,382	12,043,769		
Total	8	89,382,222			

Figure A26. ANOVA Farm_Subsidies - GVA_Farm

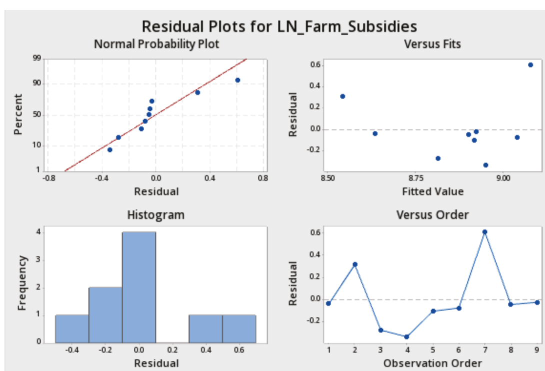

Figure A27. GVA_Agriculture–Farm_Subsidies.

Source	DF	SS	MS	F	P
Regression	2	66,767,806	33,383,903	8.86	0.016
Error	6	22,614,416	3,769,069		
Total	8	89,382,222			

Figure A28. ANOVA GVA_Agriculture–Farm_Subsidies.

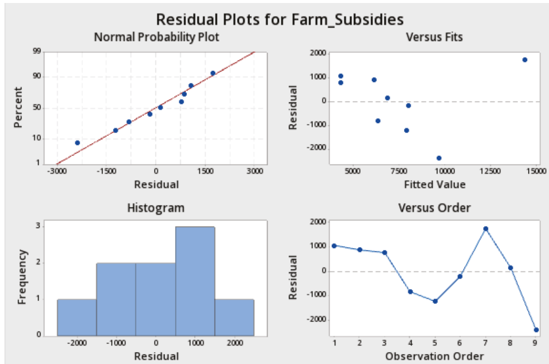

Figure A29. Subsidies–Farm_Subsidies.

Source	DF	SS	MS	F	P
Regression	2	75,831,314	37,915,657	16.79	0.003
Error	6	13,550,908	2,258,485		
Total	8	89,382,222			

Figure A30. ANOVA Subsidies–Farm_Subsidies.

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sustainability

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Review

Influences of the Industry 4.0 Revolution on the Human Capital Development and Consumer Behavior: A Systematic Review

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Abstract: Automation and digitalization, as long-term evolutionary processes, cause significant effects, such as the transformation of occupations and job profiles, changes to employment forms, and a more significant role for the platform economy, generating challenges for social policy. This systematic literature review aims to provide an overview of the research to date related to influences of the Industry 4.0 Revolution on human capital development and consumer behavior. A search on the Web of Science identified 160 papers that met the inclusion criteria. The major objectives aimed to identify: the main types of influences of the Industry 4.0 Revolution on human capital development and consumer behavior; the main opportunities and challenges for new directions in education associated with shifting the work environment; and the drivers for human capital development and consumer behavior through the lenses of the Industry 4.0 Revolution. The results revealed some key aspects for the development of human capital: information, new jobs, the Internet, technology, training, education, new skills, automation, communication, innovativeness, professionals, productivity, artificial intelligence, digitalization, e-recruitment, and the Internet of Things, as well as the main drivers of consumer behavior: information, e-commerce, digitalization, the Internet of Things, e-distribution, technology, digitalization, automation, personalized, performance, artificial intelligence, behavior intention, e-shopping, and data mining.

Keywords: industry 4.0; automation; digitalization; artificial intelligence; information technology; communication technology; human capital development; labor market; customer behavior

1. Introduction

1.1. Overview of Industrial Revolutions Through a Social Lens

Technological progress has been the engine of the development of human society since the dawn of civilization. Over time, the concerns of the scholars in economics have evolved in parallel with the evolution of technology. So far, this evolution has been marked by four major leaps, known as industrial revolutions, generated by major inventions. These inventions are the steam engine, then electricity, digitalization, and using information technology, culminating in the significant advances made in the Information and Communications Technologies (ICT) field at the end of the 20th century, together with the advent and mass generalization of the Internet, which led to the fourth industrial revolution.

In the field of manufacturing, the focus has shifted from increased production to increased productivity, then to automation, reaching connectivity, through the use of cyber-physical systems in production processes.

In the social field, the first industrial revolution (Industry 1.0) determined the evolution from the mercantile city, which grew based on the exchange of goods and products obtained from agriculture, to the industrial city, which grew based on increased productivity [1]. This transformation laid the foundations of the modern world, and by changing the social structure of human capital, the primordial importance of agriculture in the economic and social life has been taken over by industry. According to Frey and Osborne [2], people had a fear of technological unemployment. For this reason, several hundred years passed between the first knitting machine invented in 1589 by William Lee and the first industrial revolution. Moreover, this revolution led to the replacement of workers' skills by simplifying their tasks [3]. The workers took over the role of supervision, regulation, and control of the machines [4,5]. The second industrial revolution (Industry 2.0) brought the transition from the industrial city to the planned city. In the planned city, the new type of worker was exempted from the productive processes that involved gross physical labor, which has been replaced by social and security services, mechanical equipment, and total automation. The third industrial revolution (Industry 3.0) caused a transition from the planned city to the fragmented city, where industries were increasingly moving away from the markets, thus changing the economic systems and methods of production. In the fragmented city, a new economic-social order was born, separating, even more, the housing from the workplace, consumers, urban life, and research and innovation institutions. The fourth industrial revolution (Industry 4.0) brought about the transition from the fragmented city to the smart city [6]. At this current stage, the economic-social transformations do not have their roots in discovering a new form of energy, but they are based on the latest technological phenomenon—digitalization. The technology has made possible new products and services that have generated significant transformations in both personal and professional life, emphasizing the interaction between machines and people.

Tay, S. I. et al. have presented Industry 4.0 as a global change for each part of the company, through digitalization and automation, as well as through the manufacturing processes [7]. The concept of Industry 4.0 was easily and quickly accepted by the big international companies that already used techniques for the continuous improvement of the quality of processes and products and had high standards for research and development, to increase their competitiveness in the market [8]. The means of adopting this concept are self-optimization, self-knowledge, and self-personalization in the industry. In this way, workers communicate with computers rather than operate them, according to Tay, S. I. et al. [7].

1.2. Industry 4.0 in Definitions

Introduced in 2011 at the Exhibition in Hanover [9], the concept of Industry 4.0 has aroused the interest not only of producers but also of researchers. Thus, Kagermann et al. considered that the implementation of the concept of Industry 4.0 in the production sector implies the use to the maximum capacity of the power of communications technology and innovative inventions to stimulate the development of production technologies [10]. Quin et al. stated that Industry 4.0 could ensure the real development of companies by generating a reliable production environment. An important role is played by the intelligent data collection and interpretation, the correct decision making, and their timely implementation as a result of using the most advanced technologies, which allows faster data collection and interpretation procedures [11]. Schumacher et al. emphasized the network of advanced technologies in the value chain. Services, automation, robotics, artificial intelligence, the Internet of Things (IoT), and additive manufacturing are the elements that will reshape businesses in different industries. The new wave of transformations in production systems will blur the boundaries between the real world and virtual reality, causing the phenomenon of Cyber-Physical Production Systems (CPPS) [12]. In the Industry 4.0 scenario, the Cyber-Physical System contributes to the decentralization of the operational decision-making process by introducing autonomous machines, creating a modular structured intelligent factory [13]. Industry 4.0 aims to build open and intelligent manufacturing platforms for the application of information in industrial networks, bringing innovation in business models [14,15]. A smart manufacturing system needs more autonomy and sociality capabilities, as key factors of self-organized systems. Several features of Industry 4.0, namely, physical, digital, and biological worlds [16], significantly contribute to the improvement of the industrial environment, generating positive effects on governments' economies and development plans. Schwab emphasized that Industry 4.0 is one of the most important leaps in the global industry and economy [15]. Wang et al. have highlighted that Industry 4.0 makes full use of emerging technologies and rapid development of machines and tools to meet global challenges by improving industrial processes. The central concept of Industry 4.0 is the use of advanced information technology to implement IoT by integrating engineering knowledge [16]. The effects are on the production, consisting of increasing the speed of the processes, improving the efficiency of the production systems, and reducing the number of problems and the downtime, which ultimately leads to cost savings [17,18]. The results appear on the finished product, which has a higher level of quality and is more comfortable and cheaper to use and maintain. The concept of Industry 4.0 is an opportunity for development and competitiveness improvement [19]. Wyrwicka et al. have shown that moving to Industry 4.0 is an advantage to stay competitive in any industry. In this sense, modern machines and tools, which use sophisticated software and network sensors, can be used to plan, predict, adjust, and control business results, to lead to optimization of the value chain [20]. The result is a more dynamic production flow [21]. On the other hand, a significant negative effect is a disruption in job markets [22]. The complex and integrated development of science and technology corresponding to the stage of industry 4.0 will not only redesign commerce, culture, and society, but also our biology and ethics [23].

Schumacher et al. [12] synthesize the concept of Industry 4.0 as a mix of advanced technologies, which use the internet widely to support certain technologies. They use embedded systems, for integrating and combining intelligent machines with human actors, in manufacturing processes that require new types of technical data and generate high agility value chains.

Summarizing, the above definitions, several advantages of the industrial revolution 4.0 can be identified, namely: increasing economic efficiency, increasing labor productivity, flexibility and intelligence, reducing manufacturing costs, and increasing returns on investments. Regarding the increase of economic efficiency, it is noteworthy to modify the relation between human capital and ethnic capital, which is now automated. With less social capital and more technical capital, companies make decisions faster. The automation of the technical capital has resulted in high quality products and services. Increased labor productivity is primarily obtained since the downtime of the production lines has decreased, with decisions now being made automatically or semi-automatically. Production is monitored, and it is much easier to introduce new products on the manufacturing line and create opportunities for a single manufacturing operation. The production is flexible, and the factory is intelligent. Lower manufacturing costs and increased profitability result from the introduction of advanced technologies. Manufacturing costs will decrease significantly but over time. Initially, the investment costs of their implementation will be quite high, but they will be amortized over time. The benefits to the industry and the potential return on investments are what matter.

There are disadvantages to the Industrial 4.0 Revolution. The reduction of creativity can occur due to the automation of machines and the disappearance of human capital from the production technology. Human capital can generate controversy with its creativity, while devices are optimized, set up, and programmed to perform, despite the errors that may occur [23]. Increasing the unemployment rate, at least in some areas, can be another negative effect. Between the degree of production automation and the unemployment rate, there is a directly proportional relationship: the higher the degree of production automation, the higher the unemployment rate [23]. The automation of manufacturing technologies, and job computerization have dislocated much of the human capital, causing a new reconfiguration of it. On the other hand, however, the latest technologies will lead to the creation of new jobs, and there will be new production areas. The impact on environmental protection is also significant. Specific technologies and equipment that are incorporated in the production facilities of Industry 4.0 have a substantial effect on the environment. As a negative effect, data security breaches may occur. Internet of Things is an interrelational system of artificial intelligence, and companies are still working to fill the gaps in its security. The complexity of the tasks reduces its abilities. Although the production technologies of Industry 4.0 lead to an increase in product quality, they have not yet been able to solve the problem of sophisticated production. Human capital is currently the only type capable of carrying out complex, customized production tasks. Training with employees is required for new technologies. Apart from the maintenance provided to the production technologies of Industry 4.0, human capital must be trained in order to implement, operate, and maintain the automated systems properly and to ensure their continuous operation. The time frame for implementing Industry 4.0 is relatively large and requires efforts throughout industry. Initial costs are high.

1.3. Human Capital in the Industry 4.0 stage

The implementation of new technologies affects both employees operating in industries as well as organizations. The problem of the competence framework implies a three-dimensional approach, involving the level of the enterprise management, the fields of the production process and the types of competences [24]. According to Gan and Yusof, six types of effective Human Resources practices play essential roles in organizations, namely, knowledge management, HR policy making, training, recruiting, a reward system, and job design. They could improve the performance of organizations by equipping the workforce with up-to-date skills [25]. There is a need to identify the organizational strategies and their responses in adapting to the substitution of human workers by using robot and automation in this stage [26]. The Industry 4.0 Revolution is characterized by the decisive role of the efficiency of organizing the exchange of information. The structure of the technological mode of production has changed from the model: information + knowledge + innovation, corresponding to the knowledge economy, to the model: human intelligence + new information technologies + information + innovations, in the Industry 4.0 era. In this stage, the creativity of an individual, and the formation of human capital are the qualitative basis of the good. In the Industry 4.0 stage, it is necessary to adapt the education system to the new development requirements of the society; under these new conditions, only the knowledge gained will contribute to the development of Industry 4.0 and its safe development [27,28]. For Industry 4.0, depending on the industrial sector, specific skills and human tasks may be different from others, due to the divergence of processes. Some changes in terms of abilities and tasks have been observed [29]. Therefore, human capital will have significant participation in the work and will undergo a redirection of jobs and learning [30].

In the Industry 4.0 era, people are involved in the entire production system: as system designers, as workers, and as customers of manufactured goods. The requirements and needs of each individual involved in the process should be included in the system communicating needs and requirements amongst everyone involved [31].

1.4. Marketing in the Industry 4.0 stage

As the role of information and communication technologies in the purchasing process grows steadily, customer expectations also increase, forcing traders to react quickly to market movements [32,33]. Since the beginning of the Industry 4.0 era, researchers have predicted dramatic changes in the way of interaction between consumers and retailers, driven by the global use of new technologies and the imminent emergence of new efficient retail business models [34]. The integration of technology and the Internet has led to the emergence of connected customers [35]. They inform but also purchase, using a wide range of devices, such as smartphones, tablets, and laptops. This change has generated changes in the organization of marketing departments, which need to work integrated with IT and technology departments to expand consumer access to content. To remain competitive, marketers need to integrate these new devices into marketing campaigns and gain skills in using technology [36]. The use of technologies is becoming a source of key competencies and capabilities, generating sustainable competitive advantages for organizations. The use of ICT in business has also raised issues related to cybersecurity. With the emergence and spread of social networks and the use of mobile devices and related technologies, consumers are becoming more and more connected to each other and to organizations. In this new era of Industry 4.0, business models, in general, and marketing strategies, in particular, need specific innovation. Organizations and managers are looking for new ways to market products more efficiently, in an increasingly competitive environment [37].

1.5. Objectives

This demarche was performed aiming to understand the following issues:

- Identifying the main types of influences of Industry 4.0 revolution on human capital development and consumer behavior;
- Identifying the main opportunities and challenges for new directions in education required by shifting the work environment in the Industry 4.0 stage;
- Identifying the drivers for human capital development and consumer behavior in the context of the Industry 4.0 Revolution.

2. Motivation

The Industry 4.0 Revolution requires the Smart Manufacturing concept. In this new context, employee interactions with machines are defined. The interconnections created between the various actors represent defining elements of the new intelligent production systems, and the interfaces between workers and machines become key points. These characteristics require creative and inventive workers who are also endowed with expertise and skills to work in such environments. Their provider can only be an education system based on creativity, inventiveness, and knowledge [38]. In the context of Industry 4.0, human resources management faces new challenges of knowledge and skills related to new technologies and processes. To meet the needs of the present and future labor market, the development of the labor force requires the development of necessary skills. In Agolla's opinion [38], to effectively cope with the new challenges of the workplace, as defined by the Smart Manufacturing and Industry 4.0 Revolution, workers must develop specific competencies, abilities, skills, knowledge, and attitudes. They must become familiar with the technology of things (ToT), be capable of human-machine interactions, be able to access the technology-technology interfaces, proving that they possess a good understanding of the systems in the network, creativity, and innovation.

Boston Consulting Group (BCG) researchers have stated since 2015 that infrastructure and education must be adapted [39]. Manufacturers and suppliers need to consider their adaptation as they incorporate the technologies of Industry 4.0. Government, industry associations, and businesses should participate in this combined effort. The infrastructure must be fast, secure, and reliable enough for companies to be able use it for real-time data transmission. In the opinion of BCG scholars, the necessary improvements are aiming at fixed and mobile broadband services. Regarding education, BCG members stated that, on the one hand, school, training, and university programs need to be adapted and, on the other hand, entrepreneurial approaches must be strengthened, to increase the IT skills and innovation skills of the workforce. In a narrower sense, human capital management is gaining new meanings for corporate strategies. The intelligent manufacturing and Industry 4.0 Revolution involve the automation of processes, which leads to an increase in the number of workspaces with a high level of complexity, thereby requiring a high level of staff education [40].

The expectations of the industry as a result of its transition to the fourth phase of development justify EU's budgetary effort to implement the Industry 4.0 Agenda. The main benefits consist of increasing manufacturing efficiency by reducing the duration of the technological process, reducing the waste in the process chain, greater adaptability to the needs of customers, improving the quality of the products, and, finally, reducing the costs of manufactured products and reducing the waiting times for the final consumer. These led to the inclusion of the Industry 4.0 concept in the strategic development programs of some developed countries in world. Emerging economies must be an active part of this qualitative leap in industry.

The following considerations justify this analysis:

- Industry 4.0 has created new opportunities and threats that must be known and assessed to gain new competitive advantages;
- The competitive advantage of the cheap and skilled workforce is becoming increasingly visible and puts emerging economies in a deadlock on the future development model. To maintain economic growth, emerging economies need educational and training programs to develop skills, especially digital ones, which are increasingly demanded by the labor market.

3. Materials and Methods

A systematic literature review was conducted to provide an overview of the research to date related to influences of Industry 4.0 revolution on the human capital development and consumer behavior. This systematic literature review is based on Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (http://prisma-statement.org/), being prepared following the points in the report for systematic reviews and meta-analyses [41,42].

Systematic Literature Review (SLR) is a method used to identify, evaluate, and synthesize the current situation of specific research topics in the specialized literature. This technique involves localization, restrictive collection, rigorous scientific methodological analysis, and eliminating the subjective element. The purpose of SLR is building an overview, adequately documented on a specific topic and providing a correct summary of the literature, resulting in an estimate of the overall effect for a study population [43]. The systematic review is becoming increasingly important in social science research. The scientific importance of SLR comes from its emphasis on systematically identifying and collecting all available information on a specific topic. Based on this information, it is possible to determine a certain tendency specific to the theme or domain studied. In a SLR targeting research in the field of social sciences, according to [44], the high degree of variability in the studies related to the social sciences area must be considered.

Our approach to conducting this review was based on Snyder's approach [45] and consisted of four stages: (1) designing the review, (2) conducting the review, (3) analysis, and (4) writing up the review.

3.1. Information Source Search Strategy, and Identification

A detailed strategy was developed for using the Web of Science database. A search for publications addressing Industry 4.0-related concepts, as well as human capital and consumer behavior, was conducted in February-March of 2020. The Web of Science database was selected due to its broad coverage. In addition, we performed a partial search of gray literature in Google Scholar. The last search in all databases was performed on March 2, 2020.

Regarding the search for information in articles, we have included only the open access sources because of budgetary constraints. In the first search, including articles that are not open access, 2204 titles were provided. Only 762 were maintained in the analysis, satisfying the open-access condition. This could be a limitation of the research.

Figure 1 shows the initial search yielded a total of 762 records; however, 355 records were excluded due to their document type and language. We excluded conference proceedings, book series, books, and other publications. Only journal articles were included in the systematic literature review, aiming at high-quality studies ensured by the peer-review process undertaken by academic journals. Additionally, we excluded articles written in other languages than English, thus eliminating 27 records in various other languages. Besides that, we considered only open access articles, considering the necessity of studying the entire articles. The excluded publications were organized by criterion of exclusion.

The reasons for exclusion were:

- Not journal articles
- Other languages than English;
- Not open access papers;
- Studies not focusing on socio-economic aspects;
- Conceptual articles without evidence of a serious concern involving human capital or consumer behavior.

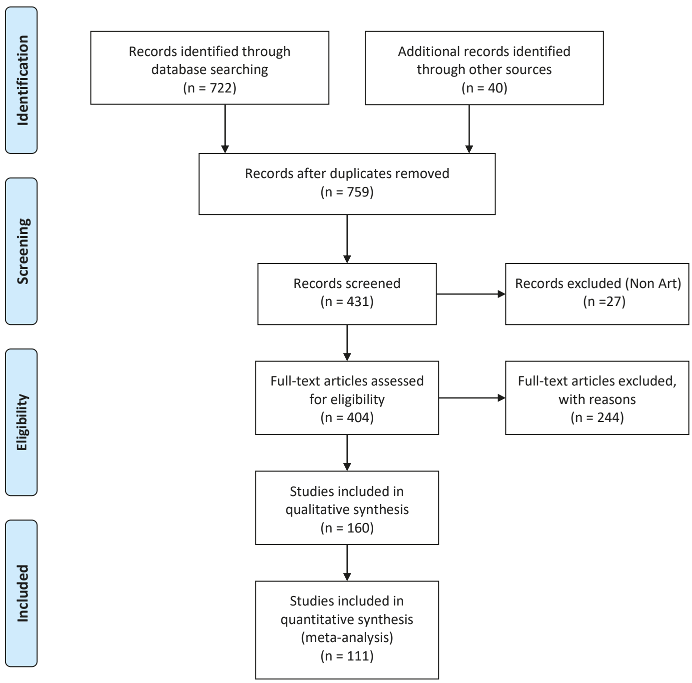

Figure 1. Flowchart of search and selection criteria. Source: Authors own design based on PRISMA.

3.2. Inclusion and Exclusion Criteria

The following combination of terms used to search references using Boolean operators was performed:

TI = (Industry 4.0* OR Industry 4.0 Revolution* OR Industrial Internet of Things* OR Internet of Things* OR Digitalization* OR Cyber-Physical Production Systems* OR Automation* OR Information Technology* OR Artificial Intelligence* OR Communication Technology*)

TS = (Human Capital Development* OR Human Resources* OR Labor market* OR Labor market* OR Consumer Behavior* OR Consumer Behavior*).

Figure 1 shows in detail the inclusion and exclusion criteria. The inclusion and exclusion process were prepared in accordance with the items of the PRISMA flow diagram and the Checklist. In the qualitative analysis, first, we screened the abstracts; 49 records were excluded because they provided no approach of the related to Influences of Industry 4.0 Revolution on the Human Capital Development and Consumer Behavior. Posteriorly, we proceeded to read the articles.

4. Results

A total of 762 articles were initially found as a result of the database interrogation. After duplicate removal, and exclusion criteria application, 160 titles and abstracts of articles were selected and read. After reading the abstracts, 111 full-text articles were analyzed in detail, meeting the eligibility criteria.

4.1. General Characteristics of the Studies

The research methodology imposed a year restriction, requesting only publication since 2011, having in sight that industry 4.0 concept was introduced in 2011. Figure 2 displays the evolution of the number of selected published articles. If during 2011–2015, the number of publications increased relatively slowly and linearly, the pace then increased sharply, with a peak in 2018. This finding suggests that the impact of information and communication technology or digitalization or automation constitutes a growing research area.

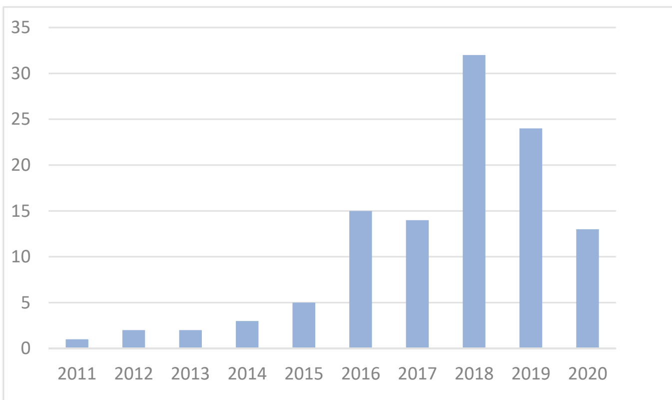

Figure 2. Number of selected published articles, per year. Source: Authors computations, based on literature surveyed.

The UK plays a leading role in the research on Industry 4.0 or related concepts and their influences on human capital or consumer behavior or management strategies and marketing practices, with a total of 25 (22.5%) publications, followed by the USA and Germany with 19 (17.1%) and 14 (13.5%) publications, respectively. A total of 23 (without Russia) countries were accounted for in the selected articles, encompassing applications mainly in Europe (76 studies corresponding to 25 publications and 13 countries). Of the 25 European publications, the most numerous are in Northern Europe, namely 10, of which 8 in the UK, where most articles have been published. It is interesting to stress that the main publication source of papers has been Western Europe, namely in Switzerland. The countries of Eastern Europe are also well represented, with a total number of 6 publications, of which 4 belong to Poland.

The first published study on Industry 4.0 [46] was from Ukraine in 2012, following the first mention of the concept in 2011 [9].

The distribution of publications by country is presented in Figure 3.

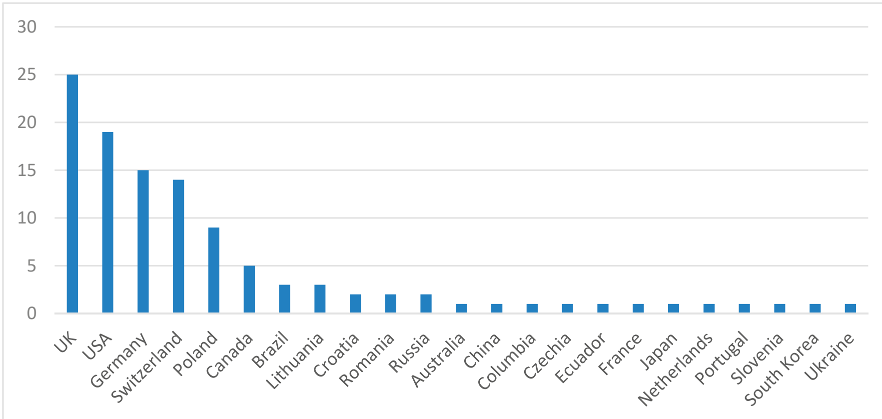

Figure 3. Number of selected published articles, by countries. Source: Authors computations, based on literature surveyed.

4.2. Main Topics Highlighted in the Literature Surveyed

Along with the topics identified by Büchi et al. [47], from the analysis carried out on the 111 articles, in our opinion, another topic can be noted, namely, marketing in the digital age. Table 1 synthesizes these twelve primary topics, which are described below.

- The phenomenon's diffusion: These changes are evident in the structure of stock exchanges, where the financial services industry wins first place [48,49]. The industrial structure of the stock indices no longer corresponds to the GDP structure, suggesting that the stock market does not reflect the economy. As a result of the growth of financial services, a new phenomenon has emerged—financing the economy and, in particular, the markets. However, significant changes in the industrial structures of GDP and stock markets are expected. The new economy is associated with new technologies. The share of GDP of traditional industries will decrease, and the percentage of GDP of robotic industries using IT will increase. These lead to the assumption that the financial services sector, which is particularly demanding for human capital, will show a downward trend in its role [50]. The transition to new technologies has to be made gradually based on national strategies. Governments need to consider a gradual change to economic and social systems based on new technologies. Problems that may arise are related to IT security, but also to the loss of many jobs [51,52].
- The impact of enabling technologies on the global economy, measured through productivity, employment and unemployment, and technological or legal changes: Digitalization will cause significant changes in the social-economic environment, but especially in terms of employment. Empirical evidence [53–55] does not show that this will generate mass unemployment. On the contrary, employment levels show remarkably robust developments in terms of both the number of employees and the hours worked. New jobs will replace traditional roles, and new business models will appear. Digitalization, as a long-term evolutionary process, has major effects, such as transformation of occupations and job profiles, changes in forms of employment, a greater role for the so-called platform economy, generating challenges for social policy [56–58]. New and emerging technologies led to the automation of jobs and the rise of entrepreneurship, causing radical transformations on labor markets [59]. The information technologies determine qualitative changes in the educational services, creating conditions for improving life and increasing the comfort level of the inhabitants, both individually and at the community level [60]. In this regard, the development of information technology can contribute to the personalized choice of the profession in the social, educational, and communications environment of a smart city. Its facilities

provide the opportunity to combine the stages of specialized training based on the needs of an individual, economic, and social development, the demands of the labor market in the city, community, or region, and the systematic aspirations of the corresponding communities [61,62]. The implementation of advances in science and technology has significantly affected not only the increase in labor productivity and economic growth. Still, it has also brought about changes in industrial structures [46,63–65]. The implementation of artificial intelligence in production systems generates, besides beneficial effects, ethical, and legal problems [66]. Labor legislation must adapt to dealing with the changes imposed by Industrial 4.0 revolution [67–69]. A reorganization of the production process is required [70,71].

- Innovation in business models: Industry 4.0 affects manufacturing industries differently. An increase in personnel costs affects the machine and plant engineering sector. After years of concern for equipment development and production, interest has shifted to software. The workforce must be qualified to adapt to the effects of IoT introduction, as a result of transforming the role of employees from being operators to being problem solvers. Industry 4.0 changes business models across different manufacturing industries. Companies are willing to support higher education institutions by investing in interdisciplinary education in the areas of economics, engineering, computer science, and mathematics for future employees. The electrical engineering and ICT sectors not only address their customers but also their customers' clients as well. Thus, "B2B2C" type relationships are developed. On the other hand, some industries are experiencing slight changes. Here we are talking about sectors that incorporate high-level technologies, such as the medical engineering sector or the automotive sector [72]. Along with Industry 4.0, servitization also contributes to the transformation of companies, focusing mainly on adding value for the customer [73]. Creating value by integrating design contributes to increasing the competitiveness of firms through innovation [74,75]. This approach allows them to acquire uniqueness, facilitating their fight against competitors, who will find it harder to imitate their business model and strategy. Companies thus acquire intelligent and sustainable competitive power [76]. Changing management approaches it is necessary to support innovative solutions [77,78]. In order to contribute to the creation of sustainable industrial values, the Industrial Internet of Things (IIoT) requires an extension of the perspective of creating the sustainable value of the Triple Bottom Line (TBL). From the economic, ecological, social, and technical dimensions, it must be supplemented with three other dimensions, namely technical integration, data and information, and public context [79]. Currently, the effects of IIoT at the business level are underestimated or too little considered, even if the companies validate their existing business model in this context [80]. SMEs play an essential role in creating industrial value. They have imposed a business model that aims to create value, capture value and offer value. The Industry 4.0 revolution affects this model, acting on three levels, namely, high-quality process digitalization, intelligent manufacturing, and connectivity between companies. The SMEs' business models also differ according to their relation with Industry 4.0: craft manufacturers, preliminary stage planners, Industry 4.0 users, and full-scale adopters [81]. Artificial Intelligence (AI) is being applied in many sectors, allowing a broad range of innovative solutions. Specific AI business models are developing, meaning companies face new challenges from regulation to human resources and data collection. Managing AI-based innovation led to increased demand for AI experts, but also for clear rules. Policies to support AI-based innovation, therefore, should focus on human aspects [82].
- Improving the value chain: Transition to Industry 4.0 means growing expectations, especially for companies that have a modern IT infrastructure. That allow all operations within an organization to be linked through computer systems and network information management. These lead to greater efficiency in the manufacturing flow and develop self-learning intelligence by taking advantage of the specific Industry 4.0 infrastructure. At the level of fully integrated production systems, "intelligent" machines and products will be able to communicate with each other. The challenge will be to find the human talents that possess specific knowledge and skills to develop

the analytical algorithms needed to implement these processes. A new type of human-machine relationship will replace the classic relationships between suppliers, companies, and customers. The machine-machine and human-machine interactions will allow for more flexible production and production customization, leading to smaller batches. In this way, companies can respond to the pressure of technological progress at the customer level, which generates customers with special needs, imposing personalized product designs [83]. It is essential that the system designers take into account the requirements and needs specific to the human factor. A particular process of mediation should act as a facilitator in this regard, creating ownership in the acceptance system and allowing a company to actively influence and control the design and use of the Industry 4.0 concept [31,84].

- Redefining the supply chain: The supply chain plays an essential role in the Industry 4.0 stage. Thus, companies have several types of distribution channels available to reach customers. They can use multi-channel, cross-channel, over-the-counter, or online commerce. Also, digitalization and accessibility to just-in-time information allow manufacturers and distributors to respond more quickly to any new issues emerging in the market and better manage their spending [85]. In the supply chain oriented to the Industry 4.0 scenario, profound changes occur, such as real-time visibility across the entire supply chain, a continuous collaboration between the chain stages. The consumer is much more involved. He wants an immediate reaction and exchange of information. He is waiting for online order confirmation, tracking an order status, or updating information on shipping and order delivery. A particularly noteworthy area is data availability, more precisely, the solutions that allow real-time tracking of operations and the avoidance of unwanted events [86]. Digitalization will completely change the business environment and organizational culture of companies. New structures of the market will emerge, customer behavior will be different, with them being much more involved in the act of buying and selling. Process automation will improve the decision-making process in organizations because the emotional factor specific to people will be eliminated. The digitalization will cause a transition from homo economicus to homo cyberneticus [87]. Scientists and practitioners aimed to understand the conceptual transformation of the supply chain under the influence of digitalization. Studies [88,89] have shown the need to consider the following issues: (1) current trends and requirements of the supply chain management; (2) digitalization effects on the classic management model.
- Product reconfigurations: Digitalization will transform classic products into intelligent products. Smart products will have new competitive advantages in the market. The intelligent product becomes a complex system that combines hardware, sensors, data storage, microprocessors, software, and connectivity in numerous ways. They add to the physical component of the classic product, an intelligent component, and a connectivity component, which gives them the qualities of being smart and connected, triggering a new era of competition [90,91]. The context is favorable to large companies, which have resources for implementing new technologies, not only in the production process but also in communication and product promotion. IoT, which will significantly influence people's behavior, will also affect the decision-making model at different stages of the buying process [92].
- New human resources competencies and skills: The labor market has undergone remarkable changes in the context of technological changes. Industry 4.0 is especially beneficial in highly developed countries, which gain a new competitive advantage, but it also causes unemployment because of high levels of automation [93]. New jobs have emerged that require new competencies and prospective skills. The educational profile of human capital is changing, and new approaches to education systems are emerging [94,95]. Human capital is transitioning from the paradigm of an initial qualification sufficient for a whole career to that of a continuous accumulation of new knowledge and skills, through periodic training once every few years. These must be correlated with the development of new personal skills related to management, risk management, leadership, self-organization, communication skills, or emotional intelligence [96,97]. Emerging technologies

make it possible to divide the classic work tasks in support of global and digital production, allowing the generation of new employment models, namely, part-time, temporary, on-demand, etc. These have advantages for certain categories of workers, (i.e., the best trained, usually younger), offering flexibility for them. They are often the beneficiaries of online recruitment platforms. Women can, in turn, become beneficiaries of the increase in the degree of digitalization, allowing them access in areas that until now, were prohibited or in which they were less represented. On the other hand, those with a low educational level and belong to disadvantaged social classes, seem to register higher degrees of risk and social insecurity [96–98]. In high-tech industries, such as the auto industry, strategies for using human capital are less dependent on process technologies themselves. Studies [99] support the importance of factors at the workplace for the relationship between automation and skills, highlighting the role of the factory in the value chain and the international division of labor. There is an important role for the institutional framework, but also for the image that a company has in the market [100].

- Developing communications between people, industrial components (equipment and machinery), and products and extending internal and external networks: In developed countries, digitalization will make the transition from organizational culture to cybersecurity culture much faster. For the development of this new type of culture, education, and research, public-private partnerships or international cooperation play essential roles [101]. The technical and technological progress has also led to the growth of high-quality products and affordable prices, requiring manufacturers to take measures consisting of the implementation of production technologies based on automation and connectivity, data, and security solutions. These require specialized personnel which are trained by the labor force providers able to generate the new skills needed to eliminate the existing skills gaps. These efforts create long-term effects, allowing businesses to maximize their profitability, leading to long-term success in improving productivity and reducing waste [102]. In a global and highly competitive market, characterized by an increasingly dynamic state, this could mean the difference between sustainability and irrelevance. Large companies have a higher capacity for innovation than SMEs. For this reason, it is essential to stimulate innovation capacity among SMEs. This can be achieved by introducing strategic planning at the level of SMEs, in conjunction with a national strategic plan [103]. The current economic activity also addresses practices that are not sustainable in the use of resources. The industrial field undergoes a paradigm shift, which will determine radical changes in production systems and the relationships between it, the use of resources, and the environment. The production systems will evolve from centralized control to decentralized control, built on the self-regulating capacity of production. From this point of view, the essence of the Industry 4.0 concept is the introduction of intelligent systems capable of self-regulation. The human, technical, and production systems will communicate with each other, being interconnected, which requires the efficient functioning of logistical processes [104]. Online recruitment platforms allow better matching between the needs of the employers and the skills of the applicants to find suitable people for certain managerial functions [105–107]. IT's influences on communication are also generating implications for marketing managers dealing with increasingly demanded consumers in today's digital environment [108].
- Sustainability: The "post-economy of artificial intelligence" is characterized by the priority of new energy sources and social communication technology. It constitutes a new economic base, which makes the transition from the "economy of deficiency" to the "economy of abundance", which involves new architectures of social order. In the economy of artificial intelligence, new complex forms appear, which will create new pressures on market institutions involving competition, innovation, and commercialization [109]. Despite the difficulties facing the developing regions of the world, the changes generated by technology have created new opportunities to address the poor management of resources and to improve human well-being [110]. The Industrial Internet of Things (IIoT) is providing economic, ecological, and social benefits for industrial factories, including sustainability benefits involving the TBL. Kiel et al. [79] developed a framework for

IIoT, extending the TBL with three dimensions called: "Data and information" referring to data processing and analysis capabilities, "Public context" describing requirements in terms of legal framework and standardization, and "Technical integration", referring to intra-and inter-company implementation of the IIoT. Some studies have highlighted geographical differences. Thus, SMEs in Germany are expected to have a smaller impact as a result of moving to Industry 4.0, considering it to be more of a challenge. In contrast, Chinese SMEs primarily see social benefits of this process [111]. The implementation of Industry 4.0 within SMEs also generates economic, ecological, technical, and social risks, the latter consisting mainly of job losses. As far as social risks are concerned, they can be controlled by re-qualifying human capital. As for the technical risks, they are mainly related to IT security and political risks. All these types of risks require a new kind of management, namely, an intelligent, synergistic, and predictive management, which is able to anticipate and manage all threats [112]. The use of new skills in information and communication technology contributes to the improvement of the functional management system [113]. Through the complex nature of digitalization and collaborative consumption, they generate new challenges for human behavior and social and business practices [114,115]. By using the latest technologies for teaching and learning, it is possible to develop the future qualified human resources needed for sustainable behavior [116]. The "post-economy of artificial intelligence" is characterized by the priority of new energy sources and social communication technology. It constitutes a new economic base, which makes the transition from the "economy of deficiency" to the "economy of abundance", which involves new architectures of social order. In the economy of artificial intelligence, new complex forms appear, which will create new competition, innovation, and commercialization pressures for market institutions [117,118]. According to Scavarda et al. [119], the global movement around themes like sustainability with the triple bottom line and Industry 4.0 allows for the establishment of a ground of connection with corporate responsibility towards society.

- Transforming internationalization processes: To be able to cope with the increasing competition in the international market, companies must innovate and internationalize at the same time. Given this context, the studies identified Industry 4.0 technologies that have the potential to increase the competitiveness of companies, namely, automation manufacturing, automation, distribution robots, self-driving vehicles, automation warehousing, digitalization, digital lean, digital reality, social media, flexibility, and horizontal and vertical integration [120]. Integration of IT resources, related human resources and communication between partner companies improve the firms' ability to manage international relations more effectively through shared control, interfirm coordination, cross-firm formalization, and hybrid centralization. These benefits increase business performance and IT capabilities help reduce potential contextual limitations and risks. Firms in international alliances should consider effective development of interfirm IT capabilities in terms of readiness of hardware and software, human resources, and organizational resources [121]. According to Strange et al. [122], the implementation of Industry 4.0 creates cyber-risks and implications for the privacy of individuals, and hence, the need for regulation. Online shopping is a global phenomenon, showing significant annual growth rates. However, buyers feel a lack of confidence, especially in the case of international purchases [123].
- Performance: Some studies show that in emerging economies, there are differences between how the adoption of different technologies of Industry 4.0 is associated with expected benefits for the product, operations, and aspects of side effects. Thus, in the case of companies focusing on differentiation, the beneficial effects appear after the implementation of product development technologies. Instead, companies that focus on reducing costs or on increasing productivity or operational flexibility should give priority to those Industry 4.0 technologies that make a significant contribution to improving the manufacturing process [124]. The large-scale transition to Industry 4.0 requires a systematic implementation of Cyber-Physical systems (CPS), which are the only ones capable of monitoring and synchronizing all information at all levels [125]. In addition,

using computer algorithms, machines connected to the network will be able to work more efficiently, collaboratively, and resiliently [126]. According to Misztal et al. [127], an increasing quality and efficiency requirements as a result of production automation lead to organizational, technical and ergonomic implications. To achieve better business performance, managers must not neglect HRM activities [128,129]. The use of information technology, communication, and internet facilities contributes to increasing the efficiency of the health systems, offering new facilities, such as telemedicine, and allowing the increase of the population's access to high-quality services [130–134].

- Marketing in the digital age: Automation is everywhere, at home, in industry and, of course, in marketing and in retail. Marketing efforts focus on attracting, converting, and retaining. Automation used for attracting customers is aiming for increased online information traffic. With the evolution of the Internet, websites have started to be an essential tool for marketing. Over the past 25 years, the importance of using the Internet has increased. The marketing in the new Industrial 4.0 revolution focuses on building filtered messages through the information we hold about consumers and on the mass customization component. The companies that will give increased importance to customizing the products as unique as possible for their clients will be the ones that will have to win the market competition [135,136]. The Internet of Things has changed the way of information dissemination by changing customer behavior. Thus, the consumer experience can be improved with the help of data mining technology. The advantages result from the creation of customer and supplier networks, focused on the consumer, and supported by the Internet of Things, big data analysis, and relational fusion technologies [137]. It is necessary to track what is the consumer profile, to whom we address, what are his interests, from what sources does he get information, if he uses or not mobile devices, where he is when he comes in contact with the message, or what occupation he has, to understand users' acceptance and willingness of use for a store app [138–140]. The changes in the economic and social environment confront retailers with significant pressures, requiring them to apply new price optimization models to improve their incomes, margins, and market share. The novelty of these models resulted from three important changes: (1) Data; (2) Analyses; and (3) Automation [141]. In the future, artificial intelligence will substantially change both marketing strategies and customer behaviors [142]. Another important aspect is data security [143]: Are consumers willing to pay for improved security?

Table 1. Main topics of the included studies. Source: Authors based on literature surveyed.

No.	Reference	Year	Topics
1	[50,51]	2018	The phenomenon's diffusion
2	[9]	2011	The impact of enabling technologies on the global economy, measured through productivity, employment and unemployment, and technological or legal changes
	[46]	2012	
	[10,63]	2013	
	[70]	2014	
	[53]	2015	
	[56,65]	2016	
	[20,59,83]	2017	
	[7,57,61,64,67,68,71]	2018	
	[52,54,60,69]	2019	
	[55,58,66]	2020	

Table 1. *Cont.*

No.	Reference	Year	Topics
3	[12,72,80]	2016	Innovation in business models
	[15,79]	2017	
	[74,75,77,78,111]	2018	
	[73,76,82]	2019	
	[62]	2020	
4	[81]	2016	Improving the value chain
	[31]	2017	
	[83]	2018	
	[84]	2019	
5	[87]	2017	Redefining the supply chain
	[85]	2018	
	[86,88,89]	2019	
6	[90]	2014	Product reconfigurations
	[11,16,92]	2016	
	[8]	2017	
	[91]	2018	
7	[40]	2016	New human resources competencies and skills
	[59,79,96,97,99]	2017	
	[5,38,93,98]	2018	
	[94,100,102]	2019	
	[95,106]	2020	
8	[101]	2015	Developing communications between people, industrial components (equipment and machinery), and products as well as extending internal and external networks
	[104,108]	2016	
	[103,113]	2018	
	[105]	2019	
	[107]	2020	
9	[110]	2014	Sustainability
	[79]	2017	
	[111,114,116,117]	2018	
	[112,115,118,119]	2019	
10	[109]	2017	Transforming internationalization processes
	[121,122]	2018	
	[120]	2020	

Table 1. *Cont.*

No.	Reference	Year	Topics
11	[123]	2012	Performance
	[130]	2015	
	[38,126,127]	2016	
	[125,128,131]	2017	
	[129]	2018	
	[124,134]	2019	
12	[132,133,144]	2016	Marketing in the digital age
	[135]	2017	
	[138]	2018	
	[140,141]	2019	
	[139]	2020	

Table 1 displays the main topics of the included studies. Looking at this through time lenses, it was found that certain issues have aroused more interest in different periods. The topic of performance was mainly addressed in 2015–2016. New human resources competencies and skills received the attention of researchers in 2017. Interest has shifted to the innovation in business models and the impact of enabling technologies on the global economy, measured through productivity, employment and unemployment, and technological or legal changes. Sustainability came first in 2019. Marketing in the digital age has become the focus of interest in 2020.

4.3. Main Types of Influences of Industry 4.0 Revolution in Human Capital Development

Given the noticeable and quick transformation and the increased reliance on modern technology [57], the question which arises is how all these are changing work, employment, methods, approaches, and processes related to human resources management field in today's corporations.

Automation and robotization of production processes will mainly affect the sectors of workers whose work is repetitive and routine, leading to the loss of many jobs, mainly affecting employees with lower education. According to many scholars [51], workers will have to acquire a different or completely new set of skills to cope with these transformations in production processes. This can help increase employment, but at the same time, it will alienate a large sector of the workforce.

Among all the transformations that Industry 4.0 brings in industrial processes, digitalization is the area that seems to affect the entire economic and social environment on the broadest scale. At the level of the labor market, it requires a new set of skills needed to meet the requirements of emerging types of work (such as platform work), as well as imposing new approaches, especially in higher education. On the other hand, at the level of higher education, as a result of the intensification of the competition following globalization and market opening, another new trend appears, namely its commercialization. The way to solve these problems involves rethinking of traditional learning methods [58].

Wyrwicka and Mrugalska [20] have shown that there is a shortage of ICT professionals in European labor markets. This lack of employees is mainly manifested in the advanced manufacturing sectors, where analysis of big data and cybersecurity are needed. At present, although various actions have been taken to stimulate the acquisition of e-skills, especially in developed countries, the younger generation does not seem particularly interested in digitalizing the workplace or working in ICT, despite the fact that they perceive this sector as being the most advantageous one.

Human capital is the key resource needed to support the efficient use of IT. The pace of technological innovation has very high values, and workplaces are changing faster than ever, while acquiring new skills has become far more important than having the right credentials, which creates new pressures both on labor market and educational systems. Thus, even people who know how to use and operate technology are required to renew and expand their skills and competencies. Therefore, the key seems to be to the education system, which must find new resources and methods to meet these challenges. Educated workers not only have the skills to use new devices, but they are more flexible, and can adapt more easily to the introduction of new technologies. Some studies have found a strong association between the level of education and IT investments [145]. These results support the hypothesis that the effects of IT on productivity are more significant in countries with high levels of education. At the same time, the role of policies to increase tertiary education is highlighted.

To increase the pace of acquisition of new skills by employees and future employees, decision-makers should consider creating IT "clusters" in places such as schools, libraries, or community centers. These could be able to provide IT packages, infrastructure, and training for users. Such integrated efforts can have more significant effects on IT productivity than a simple distribution of devices such as laptops or mobile phones in developing regions [63].

The increasing use of software, connectivity and analytics will increase the demand for employees with specific skills. Therefore, the need for skilled workers in the development of software and IT technologies will increase. This skills transformation is also a key challenge for workforce providers. To respond as adequately as possible to these challenges, a combined effort from all social actors is needed, namely the government, schools and universities, trainers, but also companies. They need to work together to adapt the curricula and to strengthen the entrepreneurial approaches increasing the IT skills and innovation skills of the workforce [39].

To understand the notions and concepts of other disciplines, they must be flexible, open to change, and have the ability to work in interdisciplinary teams. The ability to communicate, having cultural openness, and the ability to use virtual tools are essential for this.

To successfully cope with these changes, people should first develop skills such as creativity, experimentation, situational assessment, design, organization, and, last but not least, reengineering. The use of electronic means and big data tools are mandatory skills for the 4.0 engineer, who must be able to process and analyze large amounts of data from multiple sources, assess the validity of the information and its credibility, and draw relevant conclusions [20].

Agolla [38] argued that as Industry 4.0 is implemented on an ever-increasing scale, both nations and organizations need to engage in education systems that focus on knowledge beyond what is currently taught. This approach may require abandoning traditional education systems and stimulating the creativity of children from an early age to university, by focusing on learning outcomes that encourage the three components of creativity, namely, creative thinking, expertise and cognitive skills. The Industry 4.0 revolution entails a revolution in education, aiming to produce human capital capable of benefiting from the needs of the Industry 4.0 revolution for Smart Manufacturing's competitiveness.

Studying situation in EU countries, Lovric showed that education, especially at higher levels, is the critical factor in increasing the productivity of developing countries, contributing more than the implementation of ICT [46]. A high contribution to the development of human capital has a high enrollment rate in tertiary school. It turns out that education is a critical factor that must be taken into account by decision-makers to achieve positive effects on increasing productivity. The suggestion that emerges is the introduction of IT technology at an early age in schools, the development of complementary training programs, and the organization of tertiary programs for skills development.

A clear conclusion is that new educational systems must be introduced. However, this does not seem to be able to solve the problem of older workers, as Sung showed [51].

Regarding recruitment methods, promoting new jobs correctly and efficiently becomes essential. In this sense, the analyzed studies explain the importance of developing an advertising profile for Industry 4.0 jobs [107]. Technology can help achieve these goals by using data mining techniques to collect relevant information about the knowledge and skills needed in fast-changing industries. In such analyses, the extracted job profiles indicate that organizations are not looking for traditionally educated workers, but creative experts, with multidisciplinary skills, who really can contribute to increasing the performance and competitiveness of companies. These analyses can contribute to the development of human capital, helping, on the one hand, the labor force and, on the other hand, human resources professionals and labor providers, i.e., education systems. Thus, for the first category, typologies of the job profiles required in Industry 4.0 can be developed. For the second one, new ways can be identified for how to track changes in the knowledge and skills needed in Industry 4.0. For the third category, updated information on necessary changes in curricula may be provided. Last but not least, recruitment companies can benefit from exploratory analyses of job advertisements.

One of the analyzed studies [38] pointed out that the use of social platforms is a current and interesting topic both in human resource management and in marketing.

4.4. Main Types of Influences of Industry 4.0 Revolution in Consumer Behavior

Industry 4.0 will bring new benefits to customers as a result of the introduction of new technologies. As the degree of technological complexity increases, the demands of the requirements will increase, and clients with individual or even unique needs will appear. Therefore, new purchasing methods may emerge [63]. Customers can have individual requests, they can request specific functions of, or even they can purchase a single product. Customers can change their order and ideas at any time during production, even at the last minute, without being charged any fees.

In Industry 4.0 specific interconnected networks, manufacturers have to collect and analyze a massive amount of data. As a result, the issue of privacy arises as a concern for both customers and manufacturers [51,92]. This issue, which could pose a threat to privacy, will be a challenge for both parties.

People are willing to pay for improved security. The presence of security information can influence consumers and therefore influence their buying behavior. Therefore, reducing these risks would be an incentive for consumers to buy more secure devices. One of the analyzed studies [143] showed that people who receive security information (for example, using a label) may be influenced in their purchasing choices.

In the new "4.0 market", the investigation of consumer opinions will use data mining techniques much more intensively, improving the calculation tools used by marketers [74]. Consumers' willingness to use mobile applications dedicated to the information process and acquisition will also contribute to increasing the efficiency of consumer research and marketing content.

Technology is increasingly contributing to the delivery of information to the end-user. An illustrative example is Virtual Reality (VR) technology [140]. This technology can significantly increase the efficiency in the presentation of new products, improving communication and content delivery, and facilitating the flow of information between different entities in the market, which positively affects consumer behavior and their perception of products.

The smart environment is accelerating changes in customer behavior. In addition, the customer experience can be enhanced with the help of data extraction technology. While e-commerce is booming, the problem of "information overload" arises, which also causes problems for customers and companies. This problem can be solved with the e-commerce recommendation system. It can recommend information about products that meet the consumer's consumer preferences towards the target customer [137].

The widespread introduction of the Internet has had a positive impact on buying intentions, but not on trust in websites. Moreover, there are studies which have shown that there is a negative relationship between ease of use of a site and trust in that site. Three significant implications result from this, as follows: (1) The more a consumer appreciates a website for efficiency and ease of navigation, the less likely it is for the consumer to trust and submit personal information to the site. (2) The ease of use of a website is strongly correlated directly with the purchase intention. (3) There is a relationship between the skills of internet consumers and the confidence of the website, which implies that the better a person's skills using the Internet, the less resistant they are to online shopping. This is because ease of use strongly refers to the intention to purchase and may even compensate for the lack of trust that consumers may feel towards a website [123].

Consumers are increasingly using mobile devices while shopping. This behavior allows retailers to collect data on each purchase and type of consumer (age, gender, etc.), and to create databases that will later help marketing teams to improve the marketing mix [92].

On the other hand, intelligent technology brings benefits to customers in terms of increasing their information possibilities, both on the production process of the product and its use concerning their behavioral patterns [63].

The use of IoT changes the way manufacturers communicate with consumers, which becomes much more personal, increasing the accuracy of segmentation and targeting the desired audience. It can even be considered an entirely new type of direct marketing [92]. This feature can become a prerequisite for more sophisticated personalized marketing. IoT allows the creation of large networks, which will connect people, equipment, organizations, remodeling not only the style of communication and product promotion but also the expectations, perceptions and requirements of consumers to companies [92]. This will affect buying and consuming behavior.

The introduction of IoT and big data technologies has led to the growth of e-commerce. Consumer online shopping performance has improved due to the diversification of information sources. On the other hand, Fu et al. [136] have shown that the decision-making process on consumer behavior seems to be influenced by online consumer reviews.

The application of IoT technology is also useful for mobile commerce. Thus, the use of location-based services allows users to receive integrated information based on time, location and context, streamlining the shopping experience. Companies can use external incentives to get consumers to have a positive attitude towards using applications, which can affect their subsequent behavioral intent [138].

IT, IoT, digitalization, increasing population mobility and its heterogeneity contribute to changing social behavior. Thus, if in the past, certain activities (work, school, shopping, socializing) tended to take place at certain times and places, today they take place more and more in the pattern "anytime, anyplace" [114]. In addition, while previously these activities tended to be carried out "at a given time", in industry stage 4.0 work activities, shopping and personal/social activities become interactive, with the possibility of overlapping several activities in the same time frame, determining a new form of consumption, namely, collaborative consumption.

In the field of health services, the implementation of IT can bring specific benefits, both in terms of service quality and safety. The effectiveness of medical services can increase through personalization of behavioral health care [131]. The challenges facing IT in this area are significant in the field of behavioral health, due to difficulties in data standardization, lack of training of the IT provider for health, and mitigation of privacy issues. In the field of health, the implementation of Industry 4.0 technologies aims mainly at the more efficient use of available treatments and the promotion of patient-centered care. Regular use of various technologies in everyday life motivates health care providers to use technology appropriately to improve health services [115,132]. Understanding people's new habits can help create a better perspective for healthcare providers through online communication.

New technologies often change customer behavior, and artificial intelligence, even more so. AI seems to facilitate both marketers and their target audience. The former benefit from a huge volume of data for the study, and the latter benefit from reduced search costs. Studies have shown, however, that there are different degrees of influence, depending on how and when clients relate to artificial intelligence, namely the adoption of AI, the use of AI and the post-adoption of AI stage. In the stage of using AI, when clients interact with it, a low-level constructive mentality could be created. It remains to be seen what other mindsets could be determined by the AI or how an AI application should communicate with clients because communication has more substantial impacts when it matches the mindset. Davenport et al. [142] have suggested that in the phase of post-adoption of AI, clients may perceive a loss of autonomy if AI can substantially predict their preferences, as a result of which they may exhibit incorrect behaviors.

4.5. Limitations

This study presents some limitations. Regarding the search for information in articles, there is a limitation in not including articles that are not open access because of budgetary constraints. In the first search, including articles that are not open access, 2204 titles were provided. Only 762 were maintained in the analysis, satisfying the open-access condition.

5. Conclusions

5.1. Opportunities and Challenges for New Directions in Education in Industry 4.0 Stage

New technologies, mainly digitalization, information technology, and communication technology are changing how corporations produce and deliver customer service.

The development of human capital has generated, in this way, an innovative solution. Martiskova et al. [37] have stated that nowadays, human capital is not only creative but also is a super human capital.

At the heart of the 4.0 revolution is the information and communications technology, which, together with artificial intelligence, profoundly influences the economic-social environment, the life of each individual and the relationships established on a global scale. In the next decades, certain professions will be gradually taken over by industrial robots, so that a large part of the jobs will be affected. Thus, traditional roles in production, agriculture, utilities will disappear [146], but new jobs in health, education, and service delivery will emerge. However, these new jobs will require employees to acquire new skills, especially digital ones. Nowadays, the employees who are most afraid of job automation are those whose formal education is precarious. Continuous retraining of employees is the most commonly used method to reduce skill differences.

Companies need to get involved and support education. Governments must support continuing education programs. Industry 4.0 needs Education 4.0. To meet the needs of the economy in the future, Education 4.0 must be viewed from a four-dimensional perspective: vocational education, entrepreneurial education, financial education, and digital education.

5.2. Identified Drivers for Human Capital Development and Consumer Behavior in Context of Industry 4.0 Revolution

As Figure 4a shows, the analysis performed on the 111 studies, highlighted some key aspects for the development of human capital in the industry stage 4.0: information, new jobs, Internet, technology, training, education, new skills, automation, communication, innovativeness, professionals, productivity, artificial intelligence, digitalization, e-recruitment, and the Internet of Things. These factors contribute to the development of human capital in three directions, namely: (1) Reducing the number of jobs allocated to human labor; (2) Allocating a labor force to other areas that produce higher added value; (3) Increasing the demand for a labor force endowed with the skills required by new technologies.

(**a**) (**b**)

Figure 4. Word clouds arranged by area from the analyzed papers, based on word frequency in analyzed papers.

Figure 4b displays the main drivers for consumer behavior in context of industy 4.0 revolution: Information, e-commerce, digitalization, Internet of Things, e-distribution, technology, automation, personalized, performance, artificial intelligence, behavior intention, e-shopping, and data mining. These driver factors contribute to consumer behavior reshaping from four perspectives, namely: (1) Business model innovation; (2) New market trends in which online commerce is becoming increasingly important; (3) Increasing access to information and the increased volume of data with which both consumers and producers are bombarded; (4) Increasing pressure from competitors.

The economic development of the last decades has depended on the competitive advantage created by the cheap and skilled workforce. In the digital age, this advantage has eroded because the workforce must be highly qualified and ready to develop new skills. The changes generated by the industry 4.0 revolution require the adoption of new business models, production processes, and new curriculums in academic programs.

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Review

A Study of the Relative Stock Market Performance of Companies Recognized for Supporting Gender Equality Policies and Practices

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Abstract: This paper explores the relative stock market performance of well-diversified gender equality equity indices in comparison with the overall market, taking both a cross-sectoral and a financial sector approach, for the period January 2017 to March 2020, with a sample of 11 indices and 834 daily observations, and using several different statistical and econometric methods. Our results show a high level of dynamic conditional correlation of daily returns among the gender equality and the overall indices. We also found comparable levels of conditional volatility (resulting from an Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH)model) and an elevated degree of synchronization of the volatility regimes (identified by a Markov switching model). Calibrating simple linear quantile regressions, we found that the value of the slope coefficients of the hypothetical linear relationship between the gender equality indices and the overall market indices are close to one, and relatively stable in relation with the value of the quantile. Using separate Vector Autoregressive (VAR) models for the cross-sectoral indices and for the financial sector indices, we found only very little evidence of causality and spill-over effects. Based on these results, we argue that the daily returns of the gender equality indices exhibited very similar characteristics with the daily returns of the overall market indices. In our interpretation, this could mean that, limited to our sample and methods of investigation, there were not significant differences in the investors' preferences towards the equity issued by public companies committed to supporting gender equality, in comparison with their approach towards listed equity in general. It could also mean that investors do not yet anticipate the significantly different financial performance of listed companies stemming from their approach towards gender equality.

Keywords: gender equality; Environmental, Social and Governance (ESG); sustainability; equity markets; volatility; correlation; Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH); Markov switching; Dynamic Conditional Correlation (DCC); quantile regression; Vector Autoregressive (VAR)

1. Introduction

Although gender equality represents a fundamental human right, many studies show that today women are not treated equally with men in their households, local communities, or at their workplace.

Statistics show that, globally, women perform around 30%–35% of the total work hours, yet they receive only around 10% of the world's total net wages [1]. Women are underrepresented in power and in decision-making roles. They receive unequal pay for equal work and they continue to be targets of physical and mental abuse.

The UN's Sustainable Development Goals (SDGs) [2] underscore women's empowerment as an important development objective, in and of itself, and highlight the relevance of gender equality to addressing a wide range of global challenges. This report is based on the five main SDG objectives that the 2016 Sustainable Stock Exchanges (SSE) Report on Progress emphasized as being in the area that financial exchanges are capable to influence, and further analyses the contribution that these important entities can bring to the goals of sustainable development: enabling women to fully and effectively participate, and have similar opportunities with men for leadership, in all areas and at all levels where decisions are made, regarding politics, economy, or the public agenda, and other gender-equality targets related to the other sixteen SDGs.

Sustainability (sustainable development) is not a new concept. In Greek and Roman philosophy, there are reflections on the relationship between human activities and ecosystems. But the concept of sustainable development has been gradually built during the last three decades of the twentieth century. Thus, in 1987, the World Commission on Environment and Development (WCED) published the report "Our Common Future" [3], offering further details regarding what sustainable development includes, referring especially to the items related to people's relations with the environment and the responsibilities that present generations have to future generations. Knowledge sharing and capacity building are fundamental for the new ecosystem, in order to contribute to economic development. A strategic alignment, both at the macroeconomic and microeconomic level, will offer the convergence necessary for a strategic change.

Environmental, social, and governance (ESG) principles are increasingly used by investors when choosing their investments [4]. ESG criteria are also found to be helpful for investors that try to stay away from companies that, looking forward, could find themselves in significant financial risk because of a lack of preoccupation with their environmental, governmental, or social impact. Integrating climate, environmental, and social sustainability factors into financial markets and systems requires time, vision, and efforts. It also needs strong contributions from all stakeholders.

Gender diversity is an important part of ESG goals, is relevant for every community, and should be an imperative for each organization and business. For companies, a policy geared towards gender inclusion generates a positive and favorable work environment which facilitates increases in productivity due to better collaboration between employees and supports a climate more prone to innovation, one that fosters better business performance in general.

During the last few years, the public agenda has radically changed, and its main themes are more geared towards the ESG goals. Thus, it has become more relevant for a company to prove its dedication to alleviating gender inequality in the workplace. This reflects also on investors' agendas, which are increasingly adapted to the priorities of the communities and no longer only focused on optimizing the risk/return relationship. This is why not only employees, but also investors, stakeholders, and regulators, have become interested in how a listed company is performing in relation to global ESG goals, particularly in respect to gender equality aspiration.

In this context, our paper investigates the behavior of returns for three well-diversified gender equality indices in comparison with relevant overall market indices. Our study uses both cross-sectoral indices and financial sector indices, to see whether there are specific characteristics for the gender equality indices that sets them apart from the overall market. We focus mainly on the first two moments of the distribution of returns, namely mean and standard deviation, and on the correlations among indices. In order to do this, we model conditional volatilities and correlations using Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH) and Dynamic Conditional Correlation Multivariate Generalized Autoregressive Conditional Heteroskedasticity (DCC MV GARCH), respectively, and we identify the alternation of volatility regimes using a Markov switching model. We also study correlations/slope coefficients among pairs of indices resulting from quantile regressions at different percentiles and a non-restricted vector autoregressive model.

According to the results that we have obtained from studying the behavior of daily returns for the period 1 January 2017 to 12 March 2020, there are no significant differences among the overall indices and the gender equality indices in what regards the average return and conditional volatility. Also, the dynamic conditional correlations and the slope coefficients at different quantiles are very close to 1, indicating practically a similar evolution for the daily returns of the gender equality indices and the overall indices.

Gender diversity represents a new trend, influencing the literature, research studies, financial markets, investor behavior, and the real economy.

In order to be able to accurately assess how different organizations perform in relation to gender equality, investors should have good access to relevant data. Stock exchanges have the ability to enhance investors' access to information by improving the reporting requirements for issuers both in terms of quality and quantity, and including more in these requirements data on topics related to gender equality. By enhancing disclosure, the exchanges and the issuers allow investors of all kind, and especially large institutional investors, to manager risk more efficiently and effectively and to be better informed when making decisions regarding their portfolio composition [1].

Prior to the last 15–20 years, very few authors considered ESG-related information and variables when assessing factors that contribute to the performance and resilience of companies. The classic approach was to rely mainly on financial indicators related to a company's balance sheet and profit and loss accounts. Such approaches are still valid and useful today, as recent studies show. Valaskova et al. [5] concluded that such indicators (i.e., return ratios, liquidity ratios, indebtedness, turnover etc.) still represent the most significant predictors of profitability and prosperity for Slovak companies. Also, Kovacova et al. [6] analyzed the effectiveness of over 100 bankruptcy models developed in Visegrad countries using cluster and correspondence analysis, and argued that such variables continue to have significant explanatory power with regard to the performance of companies (in this case, more specifically, their capacity to avoid failure), despite the fact that the set of most relevant variables might be different from one country to another. In accordance with these findings, Kliestik et al. [7] propose a new bankruptcy model that takes into account the legal and business particularities of the Slovak economy, arguing that this approach outperforms the conventional tools, having a higher sensitivity to the deterioration of the financial solidity of companies.

During the last couple of decades, many authors have argued that companies' stances related to gender diversity are relevant for their profitability and, indirectly, for the results of those investing in the securities that they issue, thus significantly expanding the set of variables used in assessing the performance of the companies. As an example, Morgan Stanley have collected data related to this topic from many public companies in different markets, creating a proprietary database and framework that includes more than 1600 listed equities. The results of their research argue that companies that are more gender diverse perform at similar levels with others but show lower volatility, a finding which has important implications for portfolio managers and corporate boards of directors. [8].

The results from a study using a sample of French firms between 2002 and 2012, listed on the Paris Stock Exchange, show that stock market liquidity is positively and significantly associated with the presence of women directors. It was found that investors' decisions vary according to their positions in the board: women independent members decrease illiquidity costs, while the presence of female inside directors increases daily trading volume. In addition, inside women increases the firm's ability to implement better strategies that cope with economic, social, and environmental constraints, which leads investors to react positively. Surprisingly, the presence of female independent directors reduces company involvement in sustainable development projects [9].

Increasing the representation of women in boardrooms could enhance corporate reputation and increase both financial and social performance [10,11]. For instance, Boulouta [10] and Bear et al. [12] found a significant and positive effect of women directors on corporate social responsibility (CSR) and

CSR ratings. Díaz-García et al. [13], Galia and Zenou [14], and Nielsen et al. [15] also show the positive effect of gender diversity on innovation, even on radical innovations, which are usually perceived as a male-controlled arena.

Gender diversity on boards could be considered as a substitute mechanism for governance in poorly governed firms. One plausible reason is that women directors are tough controllers: they are tempted to set up better monitoring and increase public and private disclosure [16].

According to some studies, the presence of women in boardrooms could be viewed as a signal made by the firm to investors of better competence, financial and social performance, and career evolution [17]. Furthermore, women directors most often bring new resources to the firm which may enhance the corporate public image and reputation in the stock market [18].

Kirkpatrick [19] emphasizes that the "failures and weaknesses in corporate governance arrangements which did not serve their purpose to safeguard against excessive risk taking in a number of financial services companies were significantly contributing to the financial crisis".

Taking as a starting point previous studies in governance (e.g., Caprio, Laeven and Levine [20]), the analysis performed by Adams and Mehran [21] employ a sample of banking data over 34 years to examine the relationship between banks' board structure and performance. The results indicate that board independence has no influence on bank performance. Other studies on bank performance (e.g., Hermalin and Weisbach [22]) emphasize that "board composition does not seem to predict corporate performance, while board size has a negative relationship to performance."

An inverted relation between bank performance and board size and between the proportion of non-executive directors and performance is found by De Andres and Vallelado [23]. Their results show that a "bank's board composition and size are related to directors' ability to monitor and advise management and that a larger and not excessively independent board might prove more efficient in monitoring and advising functions, and create more value". The authors also point out that in an environment characterized by limited competition, tight regulation, and higher informational asymmetries, banks' boards become an important mechanism for corporate governance, as their specialized knowledge of the banking business and specific risks enables them to better design banking business conduct and monitor executive managers.

Pathan and Faff [24] studied whether specific features of board structure (in terms of the total number of members, the number of independent members, and gender equality) exhibited by large US banks and/or their holding companies are able to determine bank performance. The study concludes that both the total number of board members and the number of independent members are negatively related with bank performance, while better gender diversity is linked with improved financial performance.

Another research paper by Pathan and Skully [25] that examines the trends of boards of directors (board size, composition, and CEO duality) for a sample of 212 US bank holding companies emphasizes that board size recorded a decreasing trend over the time period considered for large and medium-sized banks, while it remained relatively stable for small banks.

Empirical studies of investors' reactions to the appointment of women directors are still rare. Lee and James [26] test stock price reactions to the announcements of female and male CEOs. They conclude that investors' reactions are significantly more negative to the announcements of female CEOs than those of male CEOs. However, they are more significant and positive when women CEOs have been promoted from within the firm than from outside the firm. Similarly, Bharath et al. [27] focus on the insider trading behavior of senior corporate executives. Despite both female and male executives making positive profits, female members earn less than their male counterparts. In fact, market responses, in the short term, are driven by the stereotype that female executives are less informed about future corporate performance than males. In addition, gender bias may exist among institutional shareholders and could lead to a decrease in stock price even when gender diversity on boards has no effect on profits. One explanation is that non-block institutional investors may sell stocks of firms with gender-diverse boards (Dobbin and Jung [28]).

Post-2008 financial crisis research studies are trying to identify the influence of banks' governance structures on the main indicators related to the capital of the bank, and their contribution to systemic risk through individual risk-taking. Angeloni [29] mentions that "the relations between capital levels, risk and governance become more complex". This approach allows for a dynamic analysis of other prudential standards (on liquidity, credit allocation and provisioning, and distribution of resources) whose accomplishment is subordinated to supporting and preserving banks' solvency, capital being considered a core measure of a bank's solvency.

By conducting a first panel regression analysis, Boitan and Niţescu [30] document that larger boards and increased gender diversity negatively contribute to increases in managerial efficiency, although the influence exerted is small. The effect of increasing the number of independent directors appointed to the board and the bank size is positively associated with the managerial efficiency of large banks. The authors challenge the general perception that increased gender diversity contribute to increased managerial efficiency.

As per IFM studies [31], "just 18 percent of firms globally are led by women, and on average, only 22 percent of board members in OECD countries are women. There is even lower representation in emerging economies, such as India at 13 percent or 8 percent in Brazil. Progress has been slow to say the least".

Another study conducted by IMF staff analyzes a sample of two million firms geographically dispersed over 34 European countries, and the results show that, in general, a higher level of gender diversity at the level of senior management is linked with better financial performance. More specifically, the IMF study concludes that replacing one male senior management position with a woman at the same level of management is linked with an increase of 8–13 basis points for the return on assets of the company.

Although progress on improving the gender diversity at the workplace is being made, the pace appears to be still very slow, and large gender gaps are still present when analyzing employment and income data. For example, data shows that the participation rate of woman in the workforce is on average 20% lower than the similar rate for men, at a global level. Also, quantitative research on legal systems across countries shows that woman only hold around three quarters of the legal rights that are afforded to men on matters related to, for example, property, inheritance, and access to financial services [32,33].

2. Materials and Methods

In this paper, our focus was to investigate whether investors' behavior in relation to listed companies that promote gender equality was different in comparison with their approach towards the general market. Given the availability of gender equality indices at a cross-sectoral level, and specifically for the financial sector, we included both directions into our research, separately. In our endeavor, we employed different methods and models, trying to distinguish whether the computed performance/risk measures are statistically different for the gender equality indices in comparison with the ones for the overall indices. Because both the overall indices and the gender equality indices are well diversified, we argue that our results can be generalized.

In short, our aim is to study the behavior of gender equality indices' returns in relation to the main market indices. Thus, we investigated the conditional volatility of the volatility regimes for the 11 indices using EGARCH and Markov regime switching models. We also computed conditional correlations among the relevant indices using a DCC MV GARCH model. Subsequently, we ran unrestricted and quantile regressions where the dependent variables were the gender equality indices and the explanatory variables were the general market indices. We also calibrated an unrestricted vector autoregressive (VAR) model and tested the eventual causal relation between its components.

2.1. Sample

Our study used daily data during the period 1 January 2017–12 March 2020. We collected USD denominated prices for eight MSCI equity indices and three Bloomberg Gender Equality indices, respectively:

- MSCI World (MXWO);
- MSCI World Financials (MXWO0FN);
- MSCI Europe (MXEU);
- MSCI Europe Financials (MXEU0FN);
- MSCI Asia Pacific (MXAP);
- MSCI Asia Financials (MXAP0FN);
- MSCI North America (MXNA);
- MSCI North America Financials (MXNA0FN);
- Bloomberg Gender Equality Index (BGEI);
- Bloomberg GEI Financials (BGEIF);
- Bloomberg GEI Excluding Financials (BGEIXF).

Thus, we have constructed a database composed of 11 time series of a daily frequency (prices and returns, respectively), each with 834 observations.

All MSCI indices used in our study are free-float weighted, including only companies from developed markets within the specific region for which the index was constructed.

The Bloomberg Gender Equality indices are modified capitalization-weighted indices that measure the price performance for listed global companies, which are recognized for periodically disclosing information and implementing policies and good practices related to gender equality. BGEI is a composite of BGEIF and BGEIXF. We used the 2020 version of the Bloomberg Gender Equality Index, which is composed of 325 companies from 11 sectors of economic activity, with a combined market capitalization of over USD 12 trillion, headquartered in 42 countries and regions. Prior to being included in the index, the companies should disclose specific information within a framework based on five dimensions, and their gender performance is assessed according to them. The five criteria are female leadership and talent pipeline, equal pay and gender pay parity, inclusive culture, pro-women brand, and anti-sexual harassment policies. Only the listed companies with a market capitalization over USD 1 billion that score above a globally established threshold, based on disclosure and best-in-class components, are included in the annual index.

2.2. Research Methodology

Step 1: preliminary data preparation and analysis

At the beginning, we stationarized all the 11 equity indices time series using the logarithmic transformation of prices into (continuously compounded) returns. Subsequently, we tested and confirmed the stationarity of each transformed time series using Augmented Dickey–Fuller and Philips–Perron unit root tests (see Appendix A, Table A1). The summary statistics for the time series are presented in Table A2.

Step 2: estimating conditional volatilities for daily returns

We used our database of 11 time series to compute daily conditional volatilities. We did this for every time series. Because in the financial literature there are many studies confirming the asymmetry of the distributions of daily returns (particularly the negative skewness), we chose to use an EGARCH (1,1) model according with Tsay [34], described by the equations below:

$$y_t = \mu + \varepsilon_t, \text{ where } \varepsilon_t = \sigma_t z_t \tag{1}$$

$$\log \sigma_t^2 = k + \sum\nolimits_{i=1}^{P} \gamma_i \log \sigma_{t-i}^2 + \sum\nolimits_{j=1}^{Q} \alpha_j \left[\frac{\left|\varepsilon_{t-j}\right|}{\sigma_{t-j}} - E\left\{ \frac{\left|\varepsilon_{t-j}\right|}{\sigma_{t-j}} \right\} \right] + \sum\nolimits_{j=1}^{Q} \xi_j \left(\frac{\varepsilon_{t-j}}{\sigma_{t-j}} \right) \tag{2}$$

Subsequently, we tested and confirmed that the coefficients of every EGARCH (1,1) model that we calibrated for each of the 11 time series are significant.

Step 3: estimating conditional correlations for daily returns

Going further in our study, we estimated conditional correlations between MSCI WORLD and all the remaining ten equity indices. In order to do this, we chose a multivariate DCC GARCH model as described by Engle and Sheppard [35] and Sheppard [36]:

$$r_t \middle| F_{t-1} \sim N(0, H_t) \text{ and } H_t = D_t R_t D_t \tag{3}$$

where Dt is a k × k diagonal matrix containing the time-varying standard deviations estimated using univariate GARCH models, with $\sqrt{h_{it}}$ found on the i^{th} diagonal, and R_t represents the matrix with similar dimension containing the time varying correlations (at time t).

The log-likelihood for the above estimator can be expressed as presented below:

$$-\frac{1}{2}\sum_{t=1}^{T}(klog(2\pi) + 2\log(|D_t|)) + \log(|R_t|) + \epsilon_t' R_t^{-1} \epsilon_t \tag{4}$$

where $\varepsilon_t \sim N(0, R_t)$ is the time series of the standardized residuals.

By expressing the components of the D_t matrix as univariate GARCH (P,Q) processes as below, we find that:

$$h_{it} = \omega_i + \sum_{p=1}^{P_i} \alpha_{ip} r_{it-p}^2 + \sum_{q=1}^{Q_i} \beta_{iq} h_{it-p} \tag{5}$$

According with these results, the structure of our dynamic correlation processes was:

$$Q_t = (1 - \sum_{m=1}^{M} \alpha_m - \sum_{n=1}^{N} \beta_n)\overline{Q} + \sum\nolimits_{m=1}^{M} \alpha_m (\epsilon_{t-m} \epsilon_{t-m}') + \sum_{n=1}^{N} \beta_n Q_{t-n} \tag{6}$$

$$R_t = Q_t^{*-1} Q_t Q_t^{*-1} \tag{7}$$

where $\overline{Q}$ represents the unconditional covariance for the time series of the standardized residuals that resulted from the initial estimation. Considering this, we note as Q^*_t the diagonal matrix containing the square root of each element situated on the diagonal of the matrix Q_t.

In addition, the elements of R_t represent the values of the time-varying correlations among the pairs of time series of indices returns and can be expressed as: $\rho_{ijt} = \frac{\sigma_{ijt}}{\sigma_{it}\sigma_{jt}}$.

As we did previously in step two, described above, we subsequently tested and confirmed that the coefficients of every DCC MV-GARCH model that we estimated are significant.

Step 4: analyzing the volatility regimes of the indices' daily returns

As previous studies also found (ex. Lupu [37]), especially during negative shocks, there is a link between the correlation and volatility, as a form of contagion in a narrow definition. We were interested to see the level of intensity at which the gender equality indices exhibit this behavior. In order to do this, we investigated whether the volatility regimes of overall indices and gender equality indices were synchronized. We estimated a Markov Regime Switching model for each time series of indices' returns, as proposed by Tsay [34], Hamilton [38,39], and Perlin [40]. The model's output represents the probabilities of the time series being either in a high-volatility or in a low-volatility regime at each period, and are described by the equation below:

$$y_t = \sum\nolimits_{i=1}^{N_{nS}} \beta_i x_{i,t}^{nS} + \sum\nolimits_{j=1}^{Ns} \varnothing_{j,S_t} x_{j,t}^{S} + \epsilon_t \qquad \epsilon_t \sim P(\Phi_{S_t}) \tag{8}$$

where N_S and N_{nS} represent the total number of the coefficients that are switching and non-switching, respectively; $x_{i,t}^{nS}$ is a subset of $x_{i,t}$ and groups the independent variables with coefficients that do not switch; $x_{i,t}^{S}$ is a subset grouping the variables with coefficients that switch; P(Φ) indicates the probability density function of the errors; and *Φ* is the vector containing the values of the parameters of *P*.

Similar to Badea et al. [41], we labeled the volatility regimes at each period by transforming the time series of probabilities resulting from the model into the time series of volatility regimes. The labels were set as chronological binary values: 1 if the respective equity index was manifesting a high volatility and 0 if the volatility regime was a quiet one. As Badea et al. [41] propose, the rules that we used to derive the values of 0 and 1 were the following:

(a) if the probability of being in a high-volatility regime > the probability of being in a low-volatility regime, the corresponding regime label is 1;
(b) if the probability of being in a high-volatility regime < the probability of being in a low-volatility regime, the corresponding regime label is 0.

Step 5: verifying the results from previous stages by two different methods: estimating the slope coefficients of simple linear quantile regressions at different percentiles and using unrestricted VAR models

We analyzed the results obtained according with the methods presented, looking for patterns to confirm whether the evolution of the performance/risk measures of the gender equality indices was different or not from the overall market indices.

Trying to validate our findings regarding the correlation between the gender equality indices and the overall market indices, we used two regression methods. We estimated simple quantile regressions where the dependent variables were the gender equality indices and the explanatory variables were the overall market indices, and we also estimated unrestricted VAR (2) models for the cross-sectoral indices and for the financial sector indices, separately.

As described in the literature on financial econometrics, linear regression describes the average linear relationship between a combination of explanatory variables and a dependent variable relying on the conditional mean expressed as E($y|x$). Because this method only offers a partial explanation of the relationship, we were interested to investigate the values of the slope coefficients between the gender equality indices and the overall market indices at several percentiles of the conditional distribution of these series, and the quantile regression is one of the tools available to do this.

In a quantile regression we express the estimator for the quantile q by minimizing the objective function described below:

$$Q(\beta_q) = \sum_{i:y_i \geq x_i'}^{N} q\left|y_i - x_i'\beta_q\right| + \sum_{i:y_i < x_i'}^{N} (1-q)\left|y_i - x_i'\beta_q\right| + \tag{9}$$

$$Q(\beta_q) = \sum_{i:y_i \geq x_i'}^{N} q\left|y_i - x_i'\beta_q\right| + \sum_{i:y_i < x_i'}^{N} (1-q)\left|y_i - x_i'\beta_q\right| \tag{10}$$

In a similar approach with other previous studies (e.g., Hammoudeh et al. [42] and Dekker et al. [43]), we investigated the linkages between the gender equality indices and the overall market indices (separately for cross-sectoral and financial sector) using a vector autoregressive model.

Because of the nature of our data, we preferred a simple unrestricted k dimensional VAR(p) model which can be described by the following equation:

$$y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + C x_t + \varepsilon_t \quad (11)$$

where $y_t = (y_1, y_2, \ldots, y_{kt})'$ is a k x 1 vector of endogenous variables, $x_t = (x_1, x_2, \ldots, x_{dt})'$ is a d x 1 vector of exogenous variables, A_1, $A_2, \ldots, A_p$, are k x k matrices of lag coefficients to be estimated, C is a k x d matrix of exogenous coefficients to be estimated, and $\varepsilon_t = (\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_{kt})'$ is a k x 1 white noise innovation process.

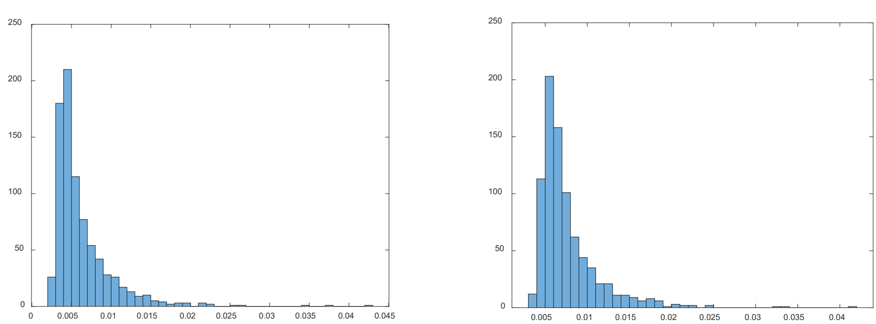
The results of our calculations made according with the methods presented above are described and discussed in the following two sections of our paper.

3. Results

One of the first thing to notice after the initial data preparation performed in step one of our methodology described above was that the overall performance (return) for the entire period (1 January 2017—12 March 2020) for the gender equality indices was mixed and inconclusive in comparison with the MSCI World indices. Still, when studying the first two moments of the distribution of daily returns, we observe that the mean values of the distributions are similar and not statistically different from zero (see Appendix A, Table A2). Also, the standard deviation is larger in comparison with the mean, and all the series present significant negative skewness and excess kurtosis. Thus, from this point of view, none of them deviates from the general characteristics of high-frequency equity returns as they were described by Cont [44]. In addition, we observe that the values of the fifth percentile of the distributions of daily returns (equivalent to 95% confidence level historical Value-at-Risk) are quite similar.

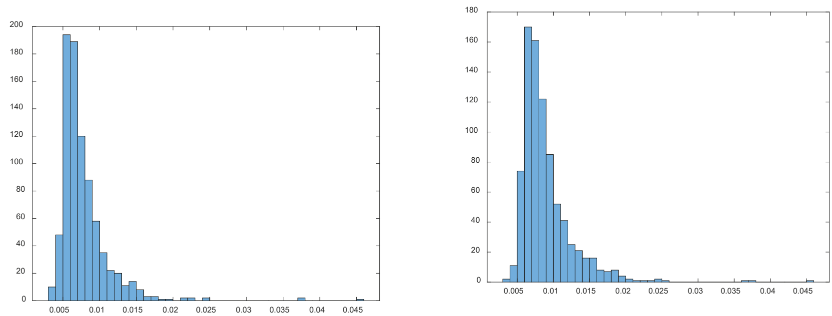
When comparing the distributions of daily conditional volatilities estimated using the EGARCH (1,1) model described in the *second stage* of our methodology, we observe, however, some small but relevant differences (see Figure 1):

- the mean and median daily conditional volatility is in general higher for the gender equality indices in comparison with their correspondent overall MSCI Indices. This also holds true for the values of the 0.95 quantile;
- the maximum and the minimum values (and, as a result, also the ranges) are comparable;
- the gender equality indices exhibit lower skewness and excess kurtosis of the daily conditional volatilities in comparison with their correspondent MSCI indices, their distributions thus being a little closer to the shape of the normal distribution.



(a) **(b)**

Figure 1. *Cont.*



(c) **(d)**

Figure 1. Comparison of the distributions of daily conditional volatilities: (**a**) MWXO; (**b**) BGEI; (**c**) MXWO0FN; (**d**) BGEIF. Source: Authors' work. Source: Authors' calculations.

Furthermore, we observe that in general the evolution of daily conditional volatility is highly synchronized between the gender equality indices and their correspondent overall MSCI indices, which already hints a high level of correlation between both the returns series and the volatility regimes, bearing in mind that linear correlation does not necessarily mean causality and spill-over (as we will argue bellow, based on our results from the VAR model). Examining Figure 2 bellow we can confirm the observation that gender equality indices in general exhibit higher daily conditional volatility (as mentioned above while interpreting the results from Table 1), and we can also observe the synchronized reaction of the indices to risk events (including the beginning of the Covid-19 pandemic in the right hand part of the charts).

Table 1. Relevant distributional characteristics of daily conditional volatility.

Daily Conditional Volatility Statistics	MXWO	BGEI	MXWO0FN	BGEIF	BGEIXF
Mean	0.006310	0.007669	0.007785	0.008994	0.006824
Median	0.005003	0.006556	0.006876	0.007990	0.005570
Kurtosis	18.708608	14.822775	31.055103	19.484522	11.878589
Skewness	3.354904	2.967020	4.153538	3.217535	2.820361
Range	0.039694	0.037731	0.041764	0.041287	0.031392
Minimum	0.002495	0.003328	0.003548	0.003983	0.002901
Maximum	0.042189	0.041060	0.045312	0.045270	0.034293
0.95 quantile	0.013551	0.015102	0.013804	0.015625	0.013472

Source: Authors' calculations.

The high level of synchronization of the daily volatility regimes is confirmed by Figure 3 below, where we present for each observation in our sample whether the volatility regimes of the two biomes of variables (BGEI vs. MXWO and BGEIF vs. MXWO0FN, respectively) were at the same level (both high or both low) or were decoupled. Going into detail, we observe that for only 48 out of 834 observations (that is, 5.76% percent of the time), the volatility regimes of the gender equality indices were not in sync with the overall MSCI indices. As previous studies concluded, the volatility regimes of the cross-sectoral indices were not necessary aligned with the ones of the financial sector indices (confirming the different behaviour of financial sector equity indices, which are more volatile in comparison with cross-sectoral diversified ones).

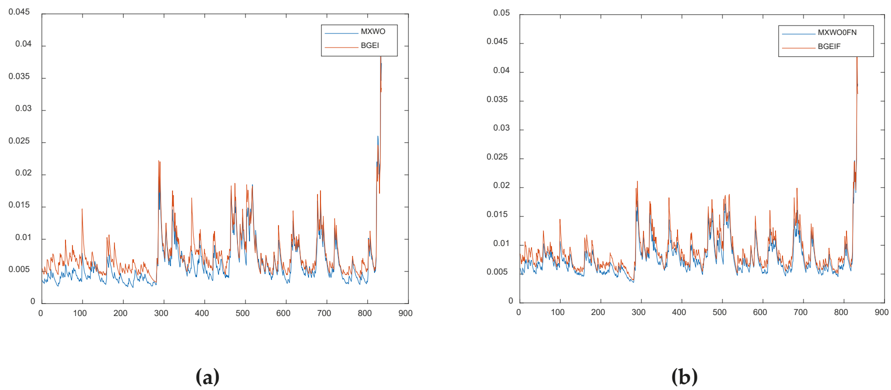


Figure 2. Comparable evolution of daily conditional volatility: (**a**) BGEI vs. MXWO; (**b**) BGEIF vs. MXWO0FN. Source: Authors' calculations.

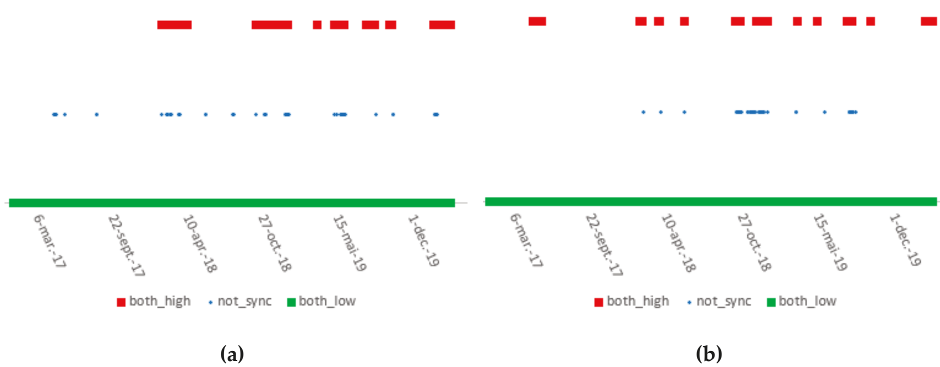


Figure 3. Comparable evolution of daily volatility regimes: (**a**) BGEI vs. MXWO volatility regimes; (**b**) BGEIF vs. MXWO0FN volatility regimes. Source: Authors' calculations.

Our results show not only that volatility and volatility regimes of gender equality indices are corelated with overall MSCI indices, but also with the returns themselves. The value of the Pearson linear correlation coefficient for the entire sample of daily returns is 0.942 for the pairing of MXWO and BGEI and 0.953 for the pair made by MXMO0FN and BGEIF, respectively (see Appendix A, Table A3). Furthermore, the study of the daily conditional correlations computed using a DCC MV GARCH (1,1) model as described in *stage three* of our methodology confirms that, during the entire period investigated by us, the conditional correlations between the gender equality indices and the overall MSCI indices were very high, indifferent of the volatility regime (see Figure 4 below). While the correlations among the financial indices appear to be more stable over time in comparison with the correlations among cross-sectoral indices, the conclusion remains that for the entire period the daily returns of the gender equality indices show a high level of linear correlation with the overall MSCI indices.

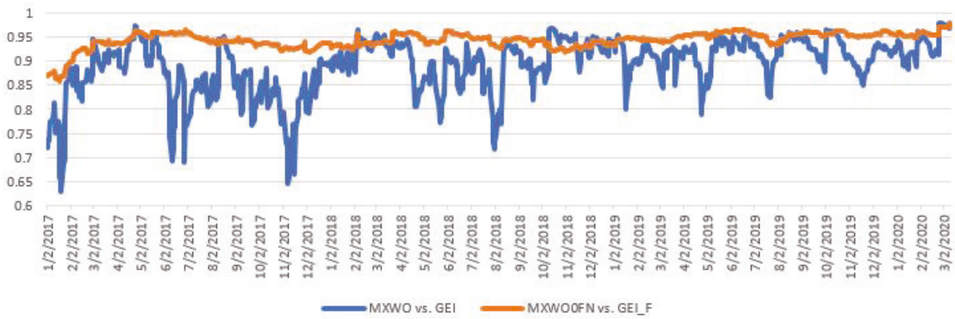
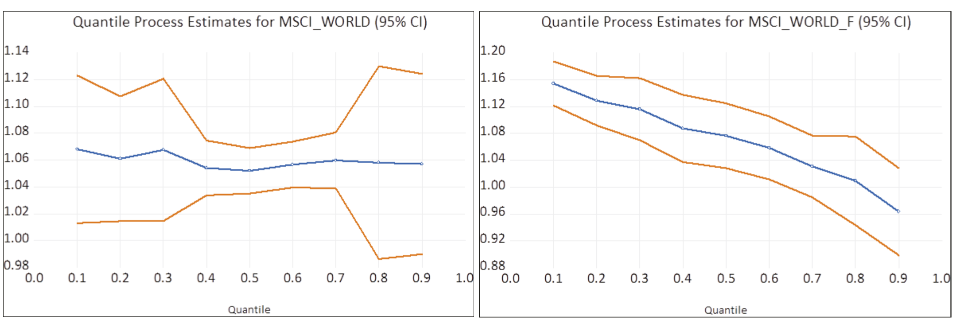


Figure 4. Evolution of dynamic conditional correlations of daily (logarithmic) returns. Source: Authors' calculations.

Going further with our analysis, we were interested to test the above findings using a different method. As described in *stage five* of our methodology, we have calibrated simple linear quantile regressions among the equity indices included in our sample, and our results presented in Appendix A, Table A4 show that all the slope coefficients (for all quantiles tested) are statistically significant. Regarding the regressions between the gender equality indices and the overall MSCI indices, the values of the slope coefficients are close to 1 and relatively stable in relation with the value of the quantile, as we can observe from Figure 5 below.



(a) **(b)**

Figure 5. Slope coefficients resulted from quantile liner regression models for daily returns: (**a**) BGEI ~ MXWO + c + ε; (**b**) BGEIF ~ MXWO0FN + c + ε. Source: Authors' work.

A more in-depth view of the results presented in Figure 5 and Appendix A, Table A4 confirms frequent findings in the financial literature that daily returns for financial sector assets are often more volatile and exhibit more skewness and fatter tails. Specifically, our results show that slope coefficients for simple linear regressions between the cross-sectoral indices are more stable in relation with the value of the quantile, while the slope coefficients for the linear regressions between the financial indices tend to be higher for the left tail quantiles, and tend to decrease for the right tail quantile. This is consistent with studies showing that, especially for financial sector assets, correlations tend to increase during bad times and decrease during good times.

For the last phase of our research, we were interested to see whether the strong link between the gender equality indices and the overall MSCI indices could be (in part) explained by causality or spill-over effects. In order to investigate this, we chose to calibrate vector autoregressive models, as described in *stage five* of our methodology, for the cross-sectoral indices and for the financial sector indices separately. The most relevant results returned by the model are presented in Figure 6.

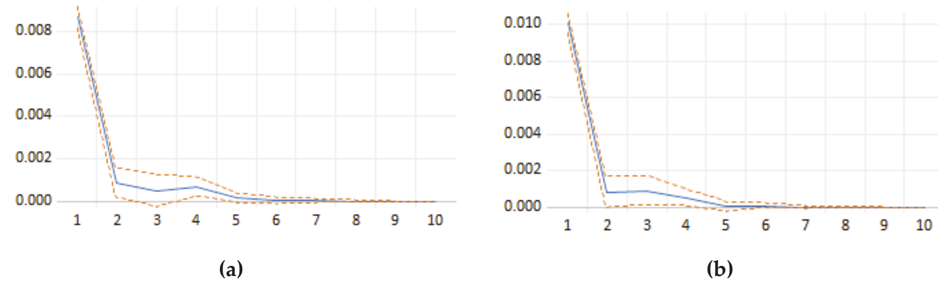


Figure 6. Response to Cholesky one s.d. (d.f. adjusted) innovations ± 2 s.e. bands derived from VAR (2) model of daily (logarithmic) returns: (**a**) response of BGEI to MXWO; (**b**) response of BGEIF to MXWO0FN. Source: Authors' work.

Based on the results (presented in detail in Appendix A, Tables A5 and A6), we argue that there is only very little evidence to support any statistically significant causality or spill-over effects from the overall market to the gender equality indices. In our view, this could mean that the high degree of correlation observed from the results of all the different models employed and presented in our study are probably mainly explained by the contemporaneous co-movement of the prices, which supports the hypothesis of the similar behaviour of investors in relation with the gender equality assets vs. the general market (entire universe of assets).

4. Conclusions

In this paper, we aimed to study the relative stock market performance of companies recognized for supporting gender equality policies and practices. In order to do this, we selected three well-diversified equity indices published by Bloomberg that are composed of companies committed to supporting gender equality through policy development, representation, and transparency: one cross-sectoral index, one financial sector index, and one index composed exclusively of non-financial companies. The cross-sectoral gender equality index is a combination of the other two, and gathers 325 companies across 11 sectors, headquarter in 42 countries and regions, with a minimum individual market capitalization of USD 1 billion and a total market capitalization of USD 12 trillion. We compare several performance metrics for these indices with similar ones computed for selected MSCI overall market indices, and especially for the MSCI World and MSCI World Financial Sector indices.

We conducted our research over a sample of 834 daily logarithmic returns from a period of more than three years (1 January 2017—12 March 2020), using several statistical methods to characterize the properties of the distribution of historical returns (mean, standard deviation, skewness, kurtosis) and correlations. We also used several econometric models to study the characteristics of dynamic conditional mean, standard deviation (volatility), correlation, causality, and spill-over effects. Namely we calibrated EGARCH (1,1) models to examine the evolution of conditional volatility, Markov switching models to investigate the synchronization of volatility regimes, DCC MV GARCH (1,1) models to describe the evolution of dynamic conditional correlations, simple linear quantile regression to analyze the values of the slope coefficients in the relations between gender equality indices and overall indices, and, finally, VAR (2) models to test for causality and spill-over effects.

Using the statistical methods described, we could not confirm any particularities for the gender equality indices in comparison with the overall indices. For our sample, the mean values of the distributions were similar and not statistically different from zero, the standard deviation was larger in comparison with the mean, all the series presented significant negative skewness and excess kurtosis, and the values of the fifth percentile of the distributions of daily returns (left tail) were quite similar. Thus, the daily returns of the gender equality indices confirmed the usual stylized facts for general equity returns described by most studies.

When comparing the distributions of daily conditional volatilities estimated using the EGARCH (1,1) model, we observed, however, some relevant differences: mean and median daily conditional volatility were, in general, higher for the gender equality indices in comparison with their correspondent overall MSCI indices. This also held true for the values of the 0.95 quantile. Also, the gender equality indices exhibited lower skewness and excess kurtosis of the daily conditional volatilities in comparison with their correspondent MSCI indices.

Overall, we found in our sample a strong link between the evolution of the gender equality indices in comparison with the overall indices. The values of daily conditional volatility were highly synchronized between the gender equality indices and their correspondent overall MSCI indices, but the gender equality indices exhibited, in general, higher daily conditional volatility.

Thus, the results obtained from our sample point in an opposite direction to the conclusions of the research conducted by Morgan Stanley [8], a situation which could be explained by the difference in sample size (ours was significantly reduced and composed of aggregated indices, not of individual issuers), sample period, and methods.

The synchronized reaction of the indices to the risk events was confirmed, including during the burst of market risk aversion at the beginning of the Covid-19 pandemic towards the end of our sample. The volatility regimes of BGEI vs. MXWO and BGEIF vs. MXWO0FN, respectively, identified using a Markov switching model, were synchronized more than 94% of the time. Furthermore, the results from the DCC MV GARCH (1,1) model showed that, during the entire period investigated by us, the conditional correlations between the gender equality indices and the overall MSCI indices were very high, with the correlations among the financial indices appearing to be more stable over time in comparison with the correlations among cross-sectoral indices.

We tested these findings using another, different, method: we calibrated simple linear quantile regressions among the equity indices included in our sample. The results obtained showed that, in the case of the regressions between the gender equality indices and the overall MSCI indices, the values of the slope coefficients are close to 1 and relatively stable in relation with the value of the quantile.

Using separate VAR (2) models for the cross-sectoral indices and for the financial sector indices, we found only very little evidence of causality and spill-over effects.

Based on the results of our analysis from several different approaches and using different econometric and statistical methods, we argue that the daily returns of the gender equality indices that we have investigated over the period 1 January 2017—12 March 2020 exhibited very similar characteristics with the daily returns of the overall market indices. Thus, we were not able to confirm the hypotheses proposed by Sanders and Boivia [17] or Singh and Vinnicombe [18] that the presence of women in boardrooms brings better perception in the stock market or is more favourably viewed by investors, inducing a different (better) share price performance in comparison with the other companies.

In our interpretation, this could mean that, limited to our sample and methods of investigation, there were no significant differences in investors' behaviour towards the equity issued by public companies committed to supporting gender equality in comparison with their approach towards listed equity in general. Accordingly, if a large selection of equity issued by companies committed to gender equality would have been included in already large diversified portfolios, it would probably not have modified their overall characteristics and performance. This is somewhat similar to presuming that, in relation with our sample and period investigated, investors were almost neutral towards large diversified portfolio of gender equality listed companies in comparison with their approach towards the overall market. It could also mean that investors do not yet manifest a specific approach in relation to this category of listed equity, or that they do not yet anticipate a significantly different financial performance of companies stemming from their approach towards gender equality.

We consider our results to be relevant for asset managers, market regulators, and supervisors, in an integrated risk based assessment framework, in order to examine how the institutional investors' strategies oriented towards gender equality ESG objectives might impact the individual and sectoral resilience to market risk.

In our research, we were limited to only a short-term approach using daily returns, because the data that we collected for the gender equality indices was only available from the beginning of 2017. As longer time series will gradually become available, our methods can also be adapted to analyze data at a lower frequency, such as weekly or monthly time series; thus enabling the inclusion of a medium-term approach into the analysis. Future studies using the same methodology could also consider dividends and other relevant corporate events, using total returns indices if available.

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Appendix A

Table A1. Results of the stationarity test for daily returns time series.

	Augmented Dicked Fuller Test			Phillips-Perron Test		
Series	**Decision (1 = reject H0)**	**Statistic**	***p*-Val.**	**Decision (1 = reject H0)**	**Statistic**	***p*-Val.**
MSCI_World	1	−11.0614	0.001	1	−22.0319	0.001
MSCI_World_F_F	1	−10.2089	0.001	1	−21.5033	0.001
MSCI_Europe	1	−9.75013	0.001	1	−21.897	0.001
MSCI_Europe_F	1	−10.1501	0.001	1	−22.5886	0.001
MSCI_Asia	1	−12.6945	0.001	1	−25.231	0.001
MSCI_Asia_F	1	−12.7513	0.001	1	−24.8486	0.001
MSCI_NA	1	−13.1364	0.001	1	−26.8434	0.001
MSCI_NA_F	1	−12.0701	0.001	1	−26.5408	0.001
GEI	1	−11.6672	0.001	1	−24.5495	0.001
GEI_F	1	−11.7046	0.001	1	−25.1067	0.001
GEI_XF	1	−11.9262	0.001	1	−23.7693	0.001

Source: Authors' calculations.

Table A2. Descriptive statistics for (logarithmic) daily returns.

Series	Mean	St Dev	*t*-Test Decision (H_0:mean = 0)	*p*-Val.
MSCI_World	0.000017	0.008277	cannot reject	0.95
MSCI_World_F_F	−0.000288	0.009785	cannot reject	0.40
MSCI_Europe	−0.000201	0.009399	cannot reject	0.54
MSCI_Europe_F	−.000489	0.011996	cannot reject	0.24
MSCI_Asia	0.000042	0.007344	cannot reject	0.87
MSCI_Asia_F	−0.000155	0.007809	cannot reject	0.57
MSCI_NA	0.000103	0.009832	cannot reject	0.76
MSCI_NA_F	−0.000197	0.011684	cannot reject	0.63
GEI	−0.000072	0.009304	cannot reject	0.82
GEI_F	−0.000192	0.010594	cannot reject	0.60
GEI_XF	0.000022	0.008492	cannot reject	0.94

Source: Authors' calculations.

Table A3. Pearson correlation coefficients for full sample of daily returns.

Correlation/t-Statistic/*p*-Value		
	MSCI_WORLD	MSCI_WORLD_F
MSCI_WORLD	1	0.911 63.595 0.000
MSCI_WORLD_F	0.911 63.595 0.000	1
MSCI_EUROPE	0.787 36.835 0.000	0.791 37.302 0.000
MSCI_EUROPE_F	0.720 29.893 0.000	0.836 43.917 0.000
MSCI_ASIA	0.558 19.401 0.000	0.547 18.872 0.000
MSCI_ASIA_F	0.519 17.498 0.000	0.565 19.751 0.000
MSCI_NA	0.966 107.817 0.000	0.850 46.619 0.000
MSCI_NA_F	0.884 54.582 0.000	0.951 89.012 0.000
GEI	0.942 81.303 0.000	0.934 75.606 0.000
GEI_F	0.901 59.764 0.000	0.953 90.519 0.000
GEI_XF	0.926 70.741 0.000	0.803 38.901 0.000

Source: Authors' calculations.

Table A4. Results of linear quantile regression models for daily (logarithmic) returns.

Specification: GEI ~ MSCI_WORLD + c + ε					**Specification: GEI_F MSCI_WORLD_F + c + ε**				
Q-Tile	**Slope Coeff.**	**Std. Error**	**t-Stat.**	***p*-Val.**	**Q-tile**	**Slope Coeff.**	**Std. Error**	**t-Stat.**	***p*-Val.**
0.1	1.0681	0.0280	38.10	0.000	0.1	1.1543	0.0167	69.05	0.000
0.2	1.0611	0.0237	44.73	0.000	0.2	1.1289	0.0188	60.03	0.000
0.3	1.0676	0.0270	39.51	0.000	0.3	1.1161	0.0235	47.43	0.000
0.4	1.0542	0.0104	101.26	0.000	0.4	1.0876	0.0255	42.68	0.000
0.5	1.0521	0.0086	121.92	0.000	0.5	1.0766	0.0246	43.75	0.000
0.6	1.0567	0.0087	121.19	0.000	0.6	1.0586	0.0239	44.34	0.000
0.7	1.0598	0.0106	99.69	0.000	0.7	1.0310	0.0234	44.04	0.000
0.8	1.0582	0.0366	28.90	0.000	0.8	1.0097	0.0337	30.00	0.000
0.9	1.0572	0.0343	30.86	0.000	0.9	0.9639	0.0331	29.15	0.000

Source: Authors' calculations.

Table A5. Results of VAR (2) model for daily (logarithmic) returns of cross-sectoral indices.

Vector Autoregression Estimates					
Date: 03/18/20; Time: 15:27					
Sample (adjusted): 1/04/2017 3/12/2020					
Included observations: 832 after adjustments					
Standard errors in ( ) & t-statistics in [ ]					
	MSCI_WORLD	GEI	MSCI_EUROPE	MSCI_ASIA	MSCI_NA
MSCI_WORLD(-1)	−0.101699	0.438906	1.481966	-0.475153	−0.317466
	(0.68781)	(0.77572)	(0.74716)	(0.51842)	(0.82361)
	[−0.14786]	[0.56580]	[1.98346]	[−0.91654]	[−0.38546]
MSCI_WORLD(-2)	1.372399	1.794611	0.950739	−0.246714	1.984110
	(0.69243)	(0.78093)	(0.75217)	(0.52190)	(0.82914)
	[1.98201]	[2.29805]	[1.26399]	[−0.47273]	[2.39299]
GEI(-1)	0.002106	−0.128624	0.060731	0.084374	−0.044455
	(0.09799)	(0.11052)	(0.10645)	(0.07386)	(0.11734)
	[0.02149]	[−1.16381]	[0.57050]	[1.14234]	[−0.37885]
GEI(-2)	0.213678	0.244558	0.341912	0.116679	0.186034
	(0.09786)	(0.11037)	(0.10631)	(0.07376)	(0.11718)
	[2.18344]	[2.21578]	[3.21627]	[1.58184]	[1.58753]
MSCI_EUROPE(-1)	0.082684	0.038537	−0.483250	0.273205	0.188152
	(0.15679)	(0.17683)	(0.17032)	(0.11818)	(0.18775)
	[0.52735]	[0.21793]	[−2.83731]	[2.31184]	[1.00216]
MSCI_EUROPE(-2)	−0.184609	−0.271758	−0.222277	0.171777	−0.276080
	(0.15919)	(0.17954)	(0.17292)	(0.11998)	(0.19062)
	[−1.15968]	[−1.51367]	[−1.28540]	[1.43167]	[−1.44834]
MSCI_ASIA(-1)	−0.001358	−0.009153	−0.063877	−0.198273	0.051226
	(0.10100)	(0.11391)	(0.10972)	(0.07613)	(0.12095)
	[−0.01344]	[−0.08035]	[−0.58218]	[−2.60443]	[0.42354]
MSCI_ASIA(-2)	−0.161878	−0.203543	−0.053529	0.010038	−0.240539
	(0.10034)	(0.11316)	(0.10900)	(0.07563)	(0.12015)
	[−1.61333]	[−1.79868]	[−0.49111]	[0.13274]	[−2.00202]
MSCI_NA(-1)	0.156951	−0.190102	−0.653943	0.620200	0.175709
	(0.45518)	(0.51336)	(0.49446)	(0.34308)	(0.54505)
	[0.34481]	[−0.37031]	[−1.32254]	[1.80773]	[0.32237]
MSCI_NA(-2)	−1.124681	−1.475558	−0.928551	0.103857	−1.547733
	(0.45584)	(0.51410)	(0.49517)	(0.34357)	(0.54583)
	[−2.46730]	[−2.87019]	[−1.87522]	[0.30229]	[−2.83554]
C	5.24E-05	−1.52E-05	−0.000220	4.50E-06	0.000177
	(0.00028)	(0.00032)	(0.00031)	(0.00021)	(0.00034)
	[0.18520]	[−0.04772]	[−0.71497]	[0.02111]	[0.52108]
R-squared	0.048677	0.040797	0.128270	0.313547	0.032490
Adj. R-squared	0.037090	0.029113	0.117652	0.305186	0.020705
Sum sq. resids	0.054288	0.069052	0.064061	0.030841	0.077841
S.E. equation	0.008132	0.009171	0.008833	0.006129	0.009737
F-statistic	4.200906	3.491879	12.08054	37.50032	2.756967
Log likelihood	2828.554	2728.479	2759.693	3063.787	2678.643
Akaike AIC	−6.772967	−6.532402	−6.607435	−7.338431	−6.412603
Schwarz SC	−6.710513	−6.469947	−6.544980	−7.275976	−6.350148
Mean dependent	1.26E-05	−8.51E-05	−0.000197	4.31E-05	9.31E-05
S.D. dependent	0.008287	0.009308	0.009404	0.007353	0.009840

Source: Authors' calculations.

Table A6. Results of VAR (2) model for daily (logarithmic) returns of financial sector indices.

Vector Autoregression Estimates					
Date: 03/18/20 Time: 15:43					
Sample (adjusted): 1/04/2017 3/12/2020					
Included observations: 832 after adjustments					
Standard errors in ( ) & t-statistics in [ ]					
	MSCI WORLD_F	MSCI EUROPE_F	MSCI ASIA_F	MSCI NA_F	GEI_F
MSCI_WORLD_F(-1)	1.172388	2.485355	0.448605	0.910761	1.486978
	(0.64743)	(0.76805)	(0.45719)	(0.78647)	(0.71161)
	[1.81082]	[3.23591]	[0.98122]	[1.15804]	[2.08960]
MSCI_WORLD_F(-2)	0.937363	0.153216	−0.147247	1.627943	1.043191
	(0.65095)	(0.77223)	(0.45968)	(0.79074)	(0.71547)
	[1.43999]	[0.19841]	[−0.32033]	[2.05876]	[1.45804]
MSCI_EUROPE_F(-1)	−0.361537	−0.815403	−0.113975	−0.255476	−0.315943
	(0.17149)	(0.20344)	(0.12110)	(0.20831)	(0.18849)
	[−2.10823]	[−4.00812]	[−0.94117]	[−1.22640]	[−1.67621]
MSCI_EUROPE_F(-2)	−0.226172	−0.089775	0.041998	−0.375660	−0.187557
	(0.17356)	(0.20590)	(0.12256)	(0.21083)	(0.19076)
	[−1.30314]	[−0.43602]	[0.34267]	[−1.78181]	[−0.98319]
MSCI_ASIA_F(-1)	−0.226105	−0.350117	−0.261596	−0.157644	−0.186965
	(0.11558)	(0.13711)	(0.08162)	(0.14040)	(0.12703)
	[−1.95630]	[−2.55354]	[−3.20518]	[−1.12284]	[−1.47177]
MSCI_ASIA_F(-2)	−0.208115	−0.088294	−0.032238	−0.309130	−0.187078
	(0.11588)	(0.13747)	(0.08183)	(0.14077)	(0.12737)
	[−1.79592]	[−0.64227]	[−0.39396]	[−2.19603]	[−1.46879]
MSCI_NA_F(-1)	−0.707879	−1.218518	−0.313872	−0.668596	−0.787334
	(0.39636)	(0.47020)	(0.27989)	(0.48147)	(0.43564)
	[−1.78597]	[−2.59150]	[−1.12141]	[−1.38866]	[−1.80730]
MSCI_NA_F(-2)	−0.829470	−0.558734	−0.082903	−1.201396	−0.806104
	(0.39393)	(0.46733)	(0.27818)	(0.47853)	(0.43298)
	[−2.10561]	[−1.19560]	[−0.29802]	[−2.51061]	[−1.86176]
GEI_F(-1)	0.237019	0.162279	0.487514	0.190637	−0.088812
	(0.12737)	(0.15110)	(0.08994)	(0.15472)	(0.13999)
	[1.86089]	[1.07400]	[5.42026]	[1.23214]	[−0.63440]
GEI_F(-2)	0.431131	0.640572	0.304395	0.374240	0.205175
	(0.12988)	(0.15408)	(0.09172)	(0.15777)	(0.14276)
	[3.31940]	[4.15741]	[3.31882]	[2.37201]	[1.43725]
C	−0.000251	−0.000471	−0.000134	−0.000143	−0.000111
	(0.00033)	(0.00039)	(0.00023)	(0.00040)	(0.00037)
	[−0.75512]	[−1.19484]	[−0.57051]	[−0.35465]	[−0.30352]
R-squared	0.059496	0.119386	0.264061	0.026511	0.028174
Adj. R-squared	0.048041	0.108660	0.255097	0.014654	0.016337
Sum sq. resids	0.074957	0.105489	0.037379	0.110607	0.090553
S.E. equation	0.009555	0.011335	0.006747	0.011607	0.010502
F-statistic	5.193655	11.13045	29.45820	2.235862	2.380119
Log likelihood	2694.345	2552.203	2983.807	2532.494	2615.713
Akaike AIC	−6.450349	−6.108662	−7.146171	−6.061284	−6.261330
Schwarz SC	−6.387894	−6.046207	−7.083717	−5.998829	−6.198876
Mean dependent	−0.000298	−0.000504	−0.000156	−0.000209	−0.000213
S.D. dependent	0.009793	0.012006	0.007818	0.011693	0.010589
Determinant resid covariance (dof adj.)		5.09E-25			
Determinant resid covariance		4.76E-25			
Log likelihood		17394.68			
Akaike information criterion		−41.68192			
Schwarz criterion		−41.36965			
Number of coefficients		55			

Source: Authors' calculations.

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