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Theory and Practice of Sustainable Economic Development

Edited by
Giedrė Lapinskienė, Dainora Gedvilaitė and Tadas Gudaitis

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Guest Editors

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Editorial

Theory and Practice of Sustainable Economic Development

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1. Introduction

The concept of sustainable development has been in use for more than 40 years. Many critics have argued that the combined use of the terms "develop" and "sustain" is an oxymoron, although it remains a prevalent concept in global development discourse. The term "Sustainable Economic Development" refers to economic development that seek to balance economic growth with environmental and social sustainability. Since the 1970s, when the Club of Rome introduced the theory of "The Limits to Growth", environmental quality has been regarded as a new prerequisite for economic progress. This shift has given rise to concepts such as the green economy, digital modernization, environmental conservation, renewable resources, and the fight against climate change as the mandatory components of economic development.

The Special Issue titled "Theory and Practice of Sustainable Economic Development" makes a broad contribution to advancing knowledge in the field of sustainability. This closing editorial aims not only to synthesize the key insights shared by our contributors but also to inspire further innovation. The journey toward sustainable economic development is not linear; it requires ongoing negotiation between theory and action, global ambition and local context, long-term vision and short-term needs. As we confront a rapidly changing climate, increasing waste, dwindling resources, widening inequality, and emerging technological disruptions, the urgency of translating sustainable development theory into practice has never been greater [1–4]. Strategies such as green finance, digital innovations, renewable energy, urban sustainability, and the green economy are essential for steering humanity toward a more balanced and sustainable future [4–7].

2. An Overview of the Published Articles

The first article, titled "Two-Way Causality Between Economic Growth and Environmental Quality: Scale in the New Capital of Indonesia", investigates the reciprocal relationship between economic development and environmental quality, particularly in the context of Indonesia's new capital city. Employing econometric analyses, the study reveals a bidirectional causality, indicating that economic growth influences environmental quality, and vice versa. This finding underscores the necessity for integrated policies that simultaneously promote economic advancement and environmental sustainability. The research highlights the importance of scale effects, suggesting that the size and scope of economic activities can significantly impact environmental outcomes. By focusing on a real-world case, the study provides empirical evidence supporting the theory that sustainable economic development must account for environmental constraints.

The second article, titled "Variability of the Level of Budget Expenditures on Social Insurance of Farmers in the Agricultural Policy of Poland After Accession to the European Union", examines changes in Poland's budgetary allocations for farmers' social insurance

following its EU accession. It highlights the significant role of the Agricultural Social Insurance Fund (KRUS) in providing social security to farmers, noting that despite Poland's integration into the EU, the structure and funding of KRUS have remained largely unchanged. The study reveals that public expenditures on farmers' social insurance have shown variability over the years, influenced by factors such as agricultural income levels, demographic shifts, and policy decisions. By analyzing budgetary trends and policy frameworks, the article underscores the challenges of aligning national agricultural social policies with broader EU standards. This research contributes to the discourse on sustainable economic development by emphasizing the need for adaptive social insurance systems that can respond to both domestic and international economic pressures.

The third article, titled "Sustainability Reporting in the University Context—A Review and Analysis of the Literature", provides a comprehensive examination of sustainability reporting practices within higher education institutions (HEIs). By systematically reviewing the existing literature, the study identifies key trends, challenges, and opportunities associated with the implementation of sustainability reporting in universities. The authors highlight that while many HEIs have adopted sustainability reporting, there is significant variability in the depth, scope, and quality of these reports. This inconsistency underscores the need for standardized frameworks and guidelines to enhance the effectiveness and comparability of sustainability disclosures in the academic sector. By advocating for improved sustainability reporting in universities, the study suggests that HEIs can serve as exemplars and catalysts for sustainable development in society at large.

The fourth article, titled "The Efficiency of Financing Environmental Protection Measures in the Context of Ukraine's Future Membership in the EU", examines the relationship between environmental protection financing and pollutant emissions in Ukraine, Poland, and Romania. Utilizing statistical data from national and European sources, the study analyzes how investments, expenditures, and environmental tax revenues influence emission levels in these countries. Findings indicate that in Ukraine, pollutant emissions are most closely linked to investments in environmental protection; in Poland, to revenues from environmental taxes; and in Romania, to direct environmental expenditures. These insights highlight the varying effectiveness of financial mechanisms across different national contexts. The research underscores the importance of tailored financial strategies to enhance environmental outcomes, especially for countries like Ukraine aspiring to align with EU environmental standards.

The fifth article, titled "Green Human Resource Management: Practices, Benefits, and Constraints—Evidence from the Portuguese Context", explores the role of Green Human Resource Management (GHRM) in promoting environmental sustainability within organizations. It highlights how GHRM practices—such as eco-friendly recruitment, training, and performance management—can foster a culture of environmental responsibility among employees. The study identifies key benefits of GHRM, including enhanced organizational reputation, increased employee engagement, and improved environmental performance. However, it also acknowledges constraints such as limited resources, lack of management support, and insufficient employee awareness that can hinder the effective implementation of GHRM practices. By providing empirical evidence from the Portuguese context, the article contributes to the broader discourse on sustainable economic development, emphasizing the importance of integrating environmental considerations into human resource management. It suggests that organizations adopting GHRM can play a pivotal role in achieving sustainability goals by aligning employee behaviors with environmental objectives.

The sixth article, titled "Research on Green Development Decision Making of Logistics Enterprises Based on Three-Party Game" by Chan He and Xu Xu, explores the dynamics of

green transformation in logistics enterprises through an evolutionary game model involving three key stakeholders, namely logistics companies, government entities, and the public. The study analyzes how varying levels of government incentives and public preference for green consumption influence logistics companies' strategic decisions towards environmental sustainability. Findings indicate that robust government supervision, combined with strong public demand for eco-friendly services, significantly motivates logistics enterprises to adopt green development strategies. Conversely, inadequate regulatory frameworks and low public engagement can deter companies from pursuing sustainable practices. By modeling these interactions, the research provides valuable insights into the mechanisms that drive or hinder green transitions in the logistics sector.

The seventh article, titled "Does Firm Size Matter for ESG Risk? Cross-Sectional Evidence from the Banking Industry" by Piotr M. Bolibok, investigates the relationship between bank size and Environmental, Social, and Governance (ESG) risk within the international banking sector. Utilizing a sample of 668 banks assessed by Morningstar Sustainalytics in 2021, the study employs both linear and non-linear regression analyses to explore this association. Findings reveal a U-shaped relationship, where ESG risk initially decreases with increasing bank size, due to better resource allocation for risk mitigation, but rises again beyond a certain size threshold, attributed to diseconomies of scale and operational inefficiencies. This nuanced understanding challenges the assumption that larger banks inherently possess lower ESG risks, highlighting the complexity of scaling sustainable practices. It underscores the importance of strategic planning in balancing expansion with sustainability objectives.

The eighth article, titled "Exploring Generation Z's Investment Patterns and Attitudes towards Greenness" by Pašiušienė et al., investigates the investment behaviors and environmental attitudes of Generation Z, emphasizing their potential role in sustainable economic development. Through a comprehensive survey, the study reveals that while Generation Z exhibits a strong theoretical commitment to environmental sustainability, there is a noticeable gap between their intentions and actual investment behaviors. The research identifies various factors contributing to this discrepancy, including limited financial resources, lack of practical investment knowledge, and perceived risks associated with green investments. By categorizing respondents based on their potential investment behaviors and applying statistical inference methods, the study provides a nuanced understanding of the heterogeneity within Generation Z regarding sustainable investment. This analysis underscores the importance of targeted financial education and policy interventions to bridge the gap between environmental values and investment actions among young individuals.

The ninth article, titled "The Assessment of Green Business Environments Using the Environmental–Economic Index: The Case of China" by Liu et al., introduces a novel framework for evaluating the green business environment (GBE) across 30 Chinese provinces and municipalities. By integrating ecological and environmental protection indicators with sustainable development metrics, the study constructs a comprehensive GBE index comprising 5 primary and 30 secondary indicators. Utilizing principal component analysis, the research ranks each region's green business environment, revealing significant disparities, with eastern provinces outperforming their central and western counterparts. This regional imbalance underscores the need for tailored policy interventions to promote equitable sustainable development across China. The study's methodology offers a replicable model for other nations aiming to assess and enhance their green business environments.

The final article, titled "Assessment of Green Banking Performance" by Giedrė Lapinskienė and Irena Danilevičienė, evaluates the effectiveness of green banking initiatives within the financial sector. Recognizing the increasing internal and external pressures on financial institutions to adopt environmentally responsible practices, the study addresses

the challenge of accurately measuring the true extent of banks' commitment to green operations. The authors develop a comprehensive assessment framework that integrates various indicators to evaluate green banking performance. By applying this framework, the study provides insights into the current state of green banking and identifies areas requiring improvement. It underscores the need for transparent and standardized evaluation methods to ensure accountability and drive meaningful progress in green banking practices.

3. Conclusions

Sustainable economic development is a multifaceted concept that requires a holistic approach to balance economic, environmental, and social goals. While significant progress has been made, ongoing challenges demand continued innovation, effective policies, and active public participation to achieve truly sustainable development. These studies collectively emphasize the critical need for integrated and context-specific policy frameworks that align economic growth with environmental sustainability. Policymakers should prioritize tailored financial instruments and incentives that enhance environmental protection investments while fostering accountability in green banking and corporate practices. Recognizing the pivotal role of organizational behavior and stakeholder engagement, policies must encourage green human resource management and incentivize eco-friendly decision-making in industries such as logistics and finance. Addressing the social dimensions, targeted support for vulnerable groups—such as farmers—and initiatives that empower younger generations through education and sustainable investment opportunities are essential to inclusive development. Finally, improving transparency through standardized sustainability reporting in educational institutions and enterprises will strengthen progress monitoring and promote long-term sustainable economic development.

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List of Contributions:

1. Nurjanana, N.; Darma, D.C.; Suparjo, S.; Kustiawan, A.; Wasono, W. Two-Way Causality Between Economic Growth and Environmental Quality: Scale in the New Capital of Indonesia. *Sustainability* **2025**, *17*, 1656. https://doi.org/10.3390/su17041656.
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Article

Assessment of Green Banking Performance

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Abstract: Internal and external pressures are pushing the financial system towards an increasingly environmentally responsible orientation. The damaging practices of green-washing necessitate the search for new ways of monitoring. The question then arises, how can one measure the actual degree of greenness of a banking industry? This study aims to create a new methodology framework to measure green performance in the banking industry using multi-criteria methods. We offer a theoretical contribution. First, a set of criteria was identified at the theoretical level. Second, the criteria were evaluated by practitioners and aggregated using the 'TOPSIS' method. This index may constitute a basis for ranking banks. The results showed that the most important factors to be considered when evaluating the performance of green banking are the greenness of the customers, the development of innovations leading to a green economy, the availability of green financial products and services, and the promotion of green education. These results lead to the conclusion that both banks and clients should become "greener" and utilize more green innovations and financial products/services.

Keywords: banking industry; green performance; multicriteria

1. Introduction

Nowadays, due to the consequences of climate change, the entire economy is in need of a core transformation, and the banking industry, using the concept of green finance, must be a leader of this transformation process. Green transformation is an approach to development that aims to move society toward sustainability in order to solve the problems brought about by climate change while simultaneously promoting digital transformation [1] and innovation acceleration [2,3]. It follows, then, that the main objective of green transformation is to achieve a balance between economic interests and nature [4]. The financial sector would therefore have to play a primary role in green transformation [5].

In modern times, banks are responsible for boosting green transformation; therefore, tracking green performance is very important. In addition to increasing society's environmental awareness, tighter regulation forces banks to take more serious actions regarding the green transformation of the economy, which it is obliged to do under increasingly stringent requirements [6]; these include Regulation 2021/2139 of the European Parliament and of the Council on the disclosure of sustainability-related information to the financial services sector, Taxonomy [7].

Considerably increased attention in the last decade has been paid to the banking industry and to their participation in transforming the economy to green. The industry's performance has been widely analysed from a financial perspective, but studies on green performance are still lacking. Environmental or ecological performance is defined as the impact of a company's operations on the natural environment [8]. The stream of academic articles related to green performance in the banking industry shows certain trends. The largest group of articles seeks answers regarding the ways in which the environmental consciousness of banking policies is validated by customers and helps to earn higher bank profits [5,8–11]. The analysis of sustainability or green performance in the banking industry

is presented by highlighting some peculiarities of green products [12–14], reporting [15,16], the focus on climate change activities [17], and Environmental, Social and Governance (ESG) strategies [18]. A focus on green performance can open a new market for smaller banks, as their clients might be willing to assume the higher risks related to green transformation compared to large banks, whose larger customers might not find green transformation to be as valuable as their financial results [10].

The aim of this paper is to fill the gap in the literature by proposing a new framework for the development of an index regarding the environmental assessment of the banking sector, as this area is still in the development process [8–16]. The function of this index is to provide bankers, professionals, and policymakers with a tool for monitoring the level of green performance of banks, taking into account the green performance of banks as organizations and their participation in the green transformation of the economy.

The study starts with a review of the literature to identify relevant green performance criteria, which are separated into two categories: profit-motivated banking services and the internal resource management of banks. Then, the analysis of the expert database and the identification of the selection criteria was performed. The analysis of expert evaluation covers the following phases: matching the compatibility of expert evaluations, identifying the weights of the chosen criteria, and assessing their significance using the TOPSIS method (Technique for Order Preference by Similarity to Ideal Solution). The TOPSIS method is a renowned compromising method for multi-criteria decision analysis and is one of the most frequently used decision-making methods.

The paper is structured as follows. Sections 2 and 3 provide essential theoretical and methodological issues based on the concepts considered. Section 4 describes the main findings of the research. Sections 5 and 6 summarises the results, provides concluding remarks, and defines possible areas for further study.

2. Literature Review

The services of the banking industry are not considered to negatively impact the environment; they have the power to redirect investments to more environmentally friendly businesses and organizations. In the scientific and practitioners' literature, the performance of green banks is analysed from the organisation side of the banks and as a transformer for the green economy. Both parts are interrelated, with each part contributing to the overall task of environmental transformation. To tackle these issues, the banking industry, similar to many other industries, has adopted Corporate Social Responsibility (CSR) and sustainability strategies.

As regards the opportunity-based approach, the banking sector is applying CSR and sustainability strategies to improve its image, as such strategies address socially sensitive issues that appear to concern consumers and customers who want to contribute to a more humanitarian and socially responsible economy. Both strategies are also used to improve brand identity, as they give the impression that banks are sensitive to and responsible for their surroundings, and such an impression might positively impact customers who wish to contribute to a green economy. To reduce environmental and social risks, many banks have implemented ESG strategies. Most organisations and banking institutions have matched their ESG strategies to the United Nations' 17 Sustainable Development Goals (17 SDGs) [19]. Both in banking and in other industries, the methodologies used play an important role, helping to constantly improve activities according to the principles of sustainability. The most used methodologies are the Global Reporting Initiative, the United Nations Global Compact, and the Environmental, Social and Governance principles [20,21]. Banks have adopted several initiatives to maintain environmental sustainability: reducing paper consumption and printing; promoting teleworking and collaboration; waste management; developing and promoting digital banking channels such as online banking, mobile banking, and digital payment machines; installing solar-powered technologies; etc. Banking sector information technology strategies can help to significantly reduce transportation, financial, and environmental costs for consumers and banking institutions,

thereby helping to maintain environmental sustainability. Several other banks have also undertaken important initiatives such as the financing of green energy projects and the adoption of green building practices, e.g., energy efficient lighting, censorship of mother fans, censorship of fan material, and duplex printing by major public broadcasters [22]. An important way to promote sustainable banking is to increase consumer acceptance of banking-related services performed via information technologies rather than via traditional branches [23].

In addition to the above, third parties have conducted various surveys and collected public information from various sources. Ratings and scores have been assigned based on company results according to the sustainability criteria defined by ESG (Bloomberg), Refinitiv Eikon, Thomson Reuters, Dow Jones sustainability, and others [24]. The S&P Global Sustainability Index Series includes a variety of indices that track the sustainability performance of companies in various sectors, including the S&P Global Banks Index, which covers banks and other financial institutions, and covers aspects such as climate transition, physical factors, natural capital, waste and pollution, and other factors of environmental risks [25].

The Refinitiv Eikon database proposes 34 variables related to the environmental aspect, grouped into three categories. The resource use efficiency category is measured by variables such as water and energy efficiency policies; environmental management systems; total energy and water consumption; usage rate of renewable energies; green buildings; and supply chain management and monitoring. The reducing emissions and waste category includes the following elements: emissions policies and targets; total carbon emissions; emissions to revenue; climate change opportunties; waste management; E-waste reduction; environmental restoration; reducing personnel transportation impacts; environmental spending; and income variables such as data regarding the financing of environmental projects, environmental products, environmental assets under management, equator principles, and clean energy products. The following discussion connects these indicators with the literature on environmental indicators, management, and performance in the banking sector [11].

The environmental performance of banks can be evaluated according to three factors: the efficient use of internal resources; the benefits resulting from investing into environmentally friendly projects; the reduction of risks associated with lending to environmentally risky industries. Banks are therefore directly involved in environmental activities, both within their organization and towards their customers and business partners. These measures can be summarized under the title 'green production', although banks are not industrial producers. Specific environmental initiatives can be divided into: (a) environmental business strategies such as concessional loans to innovative and environmentally friendly companies; (b) the selection of environmentally harmful projects in the credit evaluation process; (c) environmental philanthropy through donations to environmental causes; (d) voluntary emissions reductions such as reduced business travel; (e) environmental services through the use of electronic banking applications; (f) renewable energy for office buildings; and (g) the recycling of office waste [26,27].

The authors [15,28] evaluate the green activity of banks by distinguishing three groups of criteria: the development of green products, socially responsible initiatives, and green transformations in banking processes, assigning relevant indicators such as green credit cards, online banking, green savings accounts, or the training of employees on green initiatives. Toma and Stefanelli (2022) ranked Italian banks in terms of their green performance in terms of climate change policy, governance, risk assessment, and impact initiatives. The authors indicated that the position of each bank could vary, and that participation could depend on the size and geographic location of a given bank [17]. Gai et al. proposed a rating index that evaluates bank corporate governance decisions and internal behaviours related to environmental and social issues, as well as areas related to the stability of lending and investment activities [18]. The authors identified a list of relevant indicators for banks and their activities. Four dimensions were chosen: the field of environmental protection;

the social field; the management area; and the lending and investment areas related to ESG. The predecessor articles evaluated the ethical concepts of the banking industry and proposed the Social and Ethical Banking Index. This index, which defines the main aspects and their indicators, was constructed as follows: transparency; ethical and social assessment of investment projects from a triple-bottom-line perspective; inclusive and participatory governance; humane and sustainable structure; awareness-raising efforts [28]. The studies analysed show the main analysis directions: the environmental protection field; the social field; the management area, and the investment areas. The authors identified a list of relevant indicators for banks and their activities for each analysis direction.

In academic articles, the banks' performances were evaluated using various multicriteria methods for the financial field [29–33], for nonfinancial factors [34,35], and by those studies which considered both categories [36,37]. A few methods are appropriate for the analysis of these studies. TOPSIS, Hellwig, Delphi, and others could each be considered as appropriate, but the most appropriate of all for this phase of research is TOPSIS. The Hellwig method is not appropriate due to its low reliability and is not appropriate for the evaluation of banks. Other authors determined that the Hellwig method's correlation coefficient is smaller than that used using TOPSIS. The Delphi method is more structured and is appropriate for deep interviews with a number of experts larger than 50, which is not appropriate for the case of banks. The TOPSIS method has important advantages, including the following: (1) Explicit trade-offs and interactions between attributes are possible; (2) A preferential ranking of alternatives with a numerical value that provides a better understanding of the differences and similarities between alternatives can be provided; (3) Pairwise comparisons, which are required by methods such as the AHP, are available; (4) It is a relatively simple computational process with a systematic procedure; and (5) The TOPSIS method is more universal and can be used for the evaluation of banks. TOPSIS has been used in the banking sector, among other aspects, to evaluate financial results [38].

After reviewing the theoretical material, criteria for green outcomes in the banking sector were selected for expert evaluation. Ten criteria were selected in this phase: resource management (internal); waste management (internal); emissions management (internal); innovations leading to a green economy; internal management; external assessment; transparency; green financial products and services; education (green education); green customer review set.

3. Methodology and Data Collected

Expert evaluations represent one of the most widely developed scientific disciplines, the goals of which are the acquisition, systematic organization, structural processing, and interpretation of knowledge accumulated by a person over a long period of time using mathematical and logical methods. During the direct evaluation of the priority of objects, experts evaluate the factors according to a prespecified numerical scale, which is linked to the comparison—better/worse. For our methodology, we decided to make a concentrated questionnaire and submit closed targeted questions (defining the width of the ranking and evaluation scale). During the examination of the theoretical aspects presented in the questionnaire, measures and aspects that could promote harmony were highlighted. To avoid questions that could not be understood in the context of our research, which would therefore distort the research results, an appendix with guidelines for experts was provided along with the questionnaire. The experts were asked to compare their answers with each other according to their impact on green transformation. The experts ranked the measures and aspects presented on a scale of 1 to 10 (where 1—would have the least influence, 10—would have the most influence) (Table 1). In the second stage of the targeted part, experts evaluated each aspect and measure individually, according to their importance, thus contributing to coherence from 1 to 5 (where 1—the least important, 5—the most important).

Table 1. Alternatives to expert assessment (factors and measures).

X1	Management of Resources (internal)
X2	Waste Management
X3	Management of Emissions
X4	Innovations leading to green economy
X5	Internal Governance
X6	External assessment
X7	Transparency
X8	Green financial products and services
X9	Green education teaching
X10	Green Client Assessment

Source: Developed by the authors based on the analysis of scientific literature.

The research sample—the totality of participating experts—is determined in a probabilistic or non-probabilistic way. The essence of the probability sampling type is that it is statistically representative if the sample selected from the population is 50.01% or greater of the population, but this would be complicated by the number of respondents required to be interviewed for the study. The nonprobability basis of the selection type is a specific set of criteria formed by the researcher, according to which, suitable and unsuitable respondents are distinguished [10]. Although the research is based on the individual assessment of experts, we can call the selected respondents an expert group.

In this study, when determining the permissible number of experts, we were guided by the methodological assumptions of classical test theory, according to which, there is a rapidly decreasing non-linear relationship between the reliability of decisions made and the number of experts who make these decisionsc.

It has been shown that in expert assessment models, the accuracy of decisions and assessment of a large group of experts can be minimal, but the assessment accuracy of a group of three experts sometimes significantly exceeds the accuracy of an assessment of one or two experts. By further increasing the group of experts, the accuracy of the obtained estimates increases little by little and becomes the highest in a group of 5–9 experts [39,40]. Assuming the optimal number of experts with which the research becomes rational and reliable is 5–9 experts, 8 experts were selected for the research of this work. Based on expert selection methods and recommendations and combining them into a single set of criteria, we can say that the target working group should be assembled from eight respondents, considering their academic degree, positions held, and academic qualities, after assessing their experience working in banks and in scientific environments.

According to the set criteria (Table 2), suitable respondents (experts) were selected from various institutions and tasked with performing the following analysis:

- Determination of indicator weights
- Determining the compatibility of assessment
    - Determination of evaluations before the ranking procedure;
    - Evaluation after the ranking procedure;
    - Calculation of average ranks S and concordance coefficient W.
- Determination of weights
- Significance assessment using the TOPSIS method.
    - Expert evaluations of aspects and measures;
    - Weighted normalized values determination.
- Reorganization of indicators' weights and importance.

Table 2. Evaluation criteria of experts.

Selection Criteria	Response Evaluation
Does the respondent have an academic degree of at least a master's degree?	YES→suitable. NO→non-suitable.
Has the respondent worked for at least 5 years in institutions whose activities are related to banks or universities in the field of sustainability?	YES→suitable. NO→non-suitable.
Has the respondent worked for at least 5 years in institutions whose activities are focused on promoting sustainability?	YES→suitable. NO→non-suitable.
Has the respondent prepared presentations, given lectures, participated in expert research, seminars, trainings, or internships related to the promotion of sustainability for at least 5 years?	YES→suitable. NO→non-suitable.

Source: Compiled by the authors based on an analysis of the scientific literature.

4. Results

The assessment analysis of experts consists of steps: determining the compatibility of the assessments of the experts, determining the weights of the indicators, and assessing significance using the TOPSIS method. The analysis of the expert evaluations is followed by the summarization of all results and the presentation of conclusions.

4.1. Determination of Indicator Weights

The individual criteria that describe the influence of the research topic on the objective under consideration are not the same. Therefore, when using multi-criteria quantitative assessments, it is very important to consider the importance of the criteria, i.e., to determine their weight. Most currently known and used methods for determining the weights of multi-criteria evaluation criteria are based on expert assessments. The opinions of individual experts often do not coincide and may even be contradictory; therefore, weights as generalised averages of expert opinions can be used in a multicriteria assessment if the consistency of expert assessments is determined, i.e. if the opinions have been shown to be statistically aligned. Kendall's variance concordance coefficient can be used to determine the compatibility of assessments [41,42]. Beležentis and Žalimaitė as well as Bayanati also confirm that expert assessment is based on the assumption that a decision can only be made with consistent expert opinions [43,44]. After collecting all the data from the expert evaluation, it is necessary to assess the compatibility of the experts' opinions. If the number of experts is less than two, the correlation coefficient can be used to calculate the agreement of opinions (in this case, there are eight experts). If the number of experts is greater than two, the agreement coefficient gives the degree of expert group agreement.

Determining the Compatibility of Assessment

The set of expert evaluations is a matrix E = | | eij | | (i = 1,. . ., m; j = l,. . ., r). Here, m is the number of compared indicators, and r is the number of experts participating in the research. Each *j*-th expert evaluates each *i*-th indicator. Only the classification of expert indicators is suitable for the calculation of the dispersion concordance coefficient. If the experts evaluate the indicators in a different way, they should be preliminarily ranked, i.e., a ranking procedure should be carried out so that the most important indicator is given a rank equal to one, the second most important given a rank of two, etc. The last indicator in order of importance is rank m; where m is the number of compared indicators.

In the first part of the survey, experts had to determine the weight of the factors and measures presented according to their influence on sustainability, assigning a number from 1 to 10, respectively. The factor ranked 1 would have the least influence, while 10 would have the most influence (Table 3). In this case, the ranking procedure is necessary and is carried out for the corresponding assessment after assigning the opposite value (1).

$$e_{ij} = (e_{max} + 1) - e_{ijS}. \quad (1)$$

where e_{ij} is the evaluation value after ranking, e_{max} is the maximum evaluation value (in this case 10), e_{ijS} is the initial evaluation value. After performing the ranking procedure, reordered values are obtained that meet the requirements for calculating the dispersion concordance coefficient (Table 4).

Table 3. Initial evaluations before the ranking procedure.

Expert Code, *j*	**Alternative Number, *i***									
	X_1	**X_2**	**X_3**	**X_4**	**X_5**	**X_6**	**X_7**	**X_8**	**X_9**	**X_{10}**
E1	8	2	7	6	5	10	1	3	9	4
E2	7	8	5	6	1	10	2	3	4	9
E3	9	4	5	10	2	7	1	3	8	6
E4	6	1	5	10	4	7	3	2	8	9
E5	2	1	3	5	6	8	4	9	7	10
E6	4	1	5	7	8	2	6	10	3	9
E7	4	1	5	8	9	3	6	10	2	7
E8	8	9	10	6	7	3	4	5	2	1

Sources: Developed by the authors based on questionnaire data.

Table 4. Evaluations after completing the rank.

Expert Code, *j*	**Alternative Number, *i***									
	X_1	**X_2**	**X_3**	**X_4**	**X_5**	**X_6**	**X_7**	**X_8**	**X_9**	**X_{10}**
E1	3	9	4	5	6	1	10	8	2	7
E2	4	3	6	5	10	1	9	8	7	2
E3	2	7	6	1	9	4	10	8	3	5
E4	5	10	6	1	7	4	8	9	3	2
E5	9	10	8	6	5	3	7	2	4	1
E6	7	10	6	4	3	9	5	1	8	2
E7	7	10	6	3	2	8	5	1	9	4
E8	3	2	1	5	4	8	7	6	9	10

Source: Developed by the authors based on questionnaire data and calculations.

After the ranking procedure, the variance concordance coefficient defined by M. Kendall can be calculated. The basis of the calculation is the sum of the ranks e_i of each i, the indicator, in relation to all experts (2). In other words, the sum of the squares of the values e_i in deviation from the average rank $\bar{e}$ (4) S (analogy of variance) (3).

$$e_i = \sum_{j=1}^{r} e_{ij}. \ (i = 1, \ \ldots, m) \tag{2}$$

$$S = \sum_{i=1}^{m} (e_i - \bar{e})^2. \tag{3}$$

$$\bar{e} = \frac{\sum_{i=1}^{m} e_i}{m} = \frac{\sum_{i=1}^{m} \sum_{j=1}^{r} e_{ij}}{m}. \tag{4}$$

Theoretically, it is possible for all experts' assessments to be absolutely identical, in which case, the experts' opinions could be considered maximally harmonized S_{max} (5). Such a case would be considered ideal regarding the compatibility of expert opinions. If none of the evaluations matched, the value of S would be zero. If S is the real sum of squares, calculated according to Formula (3), then the concordance coefficient W, when

there are no associated ranks, is defined by the ratio of the sum of squares of the average rank S and the maximally agreed opinion of experts' assessments S_{max} (6).

$$S_{max} = \frac{r^2 m(m^2-1)}{12}. \quad (5)$$

$$W = \frac{12S}{r^2 m(m^2-1)} = \frac{S}{S_{max}}. \quad (6)$$

If the experts' opinions agree, the value of the concordance coefficient W approaches unity W 1. If the evaluations differ, the value of W approaches zero W 0.

When adapting to a specific research case, the compatibility of the experts' assessments was determined, i.e., the concordance coefficient (Table 5). It is estimated that the sum of all ranks $\sum_{i=1}^{r} e_i = 440$, the average of ranks $\bar{e} = \frac{440}{10} = 44$, the sum of squares of the deviation from the mean rank $S = 954$, and the sum of the maximum squares of deviation $S_{max} = \frac{8^2 10(10^2-1)}{12} = 5280$; thus, the concordance coefficient $W = 0.18$.

Table 5. Calculation of dispersion concordance coefficient.

Alternative Number, *i*	$\mathbf{X_1}$	$\mathbf{X_2}$	$\mathbf{X_3}$	$\mathbf{X_4}$	$\mathbf{X_5}$	$\mathbf{X_6}$	$\mathbf{X_7}$	$\mathbf{X_8}$	$\mathbf{X_9}$	$\mathbf{X_{10}}$	
The sum of ranks, e_i	40	61	43	30	46	38	61	43	45	33	440
Deviation from mean rank$(e_i - \bar{e})$ And average rank, $\bar{e}$	−4	17	−1	−14	2	−6	17	−1	1	−11	44
Squares of the deviation from the mean rank $(e_i - \bar{e})^2$ and their sum, S	16	289	1	196	4	36	289	1	1	121	954
Maximum matched estimates, S_{max}						5280					
Concordance coefficient, W						0.18					

Source: Compiled by the authors based on calculations.

Based solely on this concordance coefficient, it would be difficult to prove whether the opinions of the experts are aligned, since the number of indicators considered is more than seven; therefore, an evaluation of the importance of the concordance coefficient is recommended. M. Kendall proved that if the number of indicators $m > 7$, the significance of the concordance coefficient can be determined using the χ^2 Pearson criterion. The random variable (7) is distributed according to the χ^2 distribution with $\nu = m - 1$ degrees of freedom. According to the chosen significance level α (in practice, 0.05 or 0.01 is usually used), the critical value is found in the distribution table with $\nu = m - 1$ degree of freedom. If the value of χ^2 calculated in (7) is greater than the critical value of χ^2_{kr}, it is considered that the experts' assessments are in agreement. However, attention is drawn to the fact that when the number of indicators compared by m is from three to seven, the χ^2 distribution should be applied with caution, because the critical χ^2_{kr}. The value of the distribution may be higher than the calculated value, although the level of agreement of the experts' opinions is still sufficient. In such a case, it is possible to apply probabilistic tables of the concordance coefficient (with $3 \leq m \leq 7$) or S tables of critical values [41].

$$\chi^2 = Wr(m-1) = \frac{12rS(m-1)}{r^2 m(m^2-1)} = \frac{12S}{rm(m+1)}. \quad (7)$$

In a specific case, $\chi^2 = \frac{12*44}{8*10(10+1)} = 29{,}697$ $\chi^2 = \frac{12*44}{8*10(10+1)} = 29{,}697$, the calculated degree of freedom $\nu = 10 - 1 = 11$, the significance level $\alpha = 0.05$ is chosen, then the critical χ^2_{kr}. The value from the difference table is $\chi^2_{kr} = 16.92$. After comparing the obtained results, we see that $\chi^2 > \chi^2_{kr}$, which means that the experts' opinions are considered statistically aligned, so it is possible to calculate the weight of each indicator.

4.2. Determination of Weights

As in the calculation of the consensus of opinions, we will denote the results of the expert evaluation by e_{ij} and place the matrix E = | |eij| | (i = 1,. . ., m; j = l,. . ., r), where m is the number of indicators compared and r is the number of experts participating in the study. When calculating the dispersion coefficient of concordance, we had to perform a ranking procedure (1) for expert evaluations while calculating the weights. Here, it is necessary to rearrange the results again. The goal of reordering is to assign weights in descending order. This way, the highest (first) position gets the highest value. The most accurate result is provided by a linear transformation of the estimates [41,42]. In this case, the criteria weight values can be calculated according to Equation (8).

$$\omega_i = \frac{\sum_{j=1}^{r}(m+1-e_{ij})}{\sum_{i=1}^{m}\sum_{j=1}^{r}(m+1-e_{ij})}. \quad (8)$$

After rearranging and calculating the results of the evaluations, we obtained the weights of the indicators, of which the highest of the weights reflects the most influential indicator and vice versa.

As can be seen in Table 6, innovations leading to a green economy have the greatest weight in the process of green banking performance $(X_4 = 0.1318)$. An additional important aspect is $(X_{10} = 0.1250)$, the green client's assessment. All other aspects and measures follow.

Table 6. Reorganised indicator weights.

Indicator Number	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
Rearranged indicator weights, ω_i	0.1091	0.0614	0.1023	**0.1318**	0.0955	0.1136	0.0614	0.1023	0.0977	**0.1250**

Source: Developed by the authors based on calculations.

4.3. Significance Assessment Using the TOPSIS Method

In the first stage of the targeted part, the experts evaluated aspects and measures by ranking them and comparing them with each other. In the second stage, the experts were asked to rate each aspect or measure separately, according to their importance, as related to the promotion of sustainability, from 1 to 5, where 1 is the least important and 5 is the most important (Table 7). We used the TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) method to process the collected data. The TOPSIS method is a multi-criteria method with profound theoretical and practical significance.

Table 7. Expert evaluations of individual aspects and measures.

Expert Code, *j*	**Alternative Number, *i***									
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
E1	5	3	4	4	2	5	1	3	4	3
E2	5	4	5	5	1	5	1	2	5	5
E3	5	3	4	5	3	5	3	3	5	4
E4	4	4	4	5	3	4	3	4	5	5
E5	2	2	4	5	5	5	5	5	5	5
E6	3	3	4	4	5	3	5	5	4	5
E7	3	3	3	4	5	2	5	5	4	4
E8	5	5	5	4	5	3	3	4	3	2

Source: Developed by authors based on survey data.

The main principle of this method is to select, from the compared objects, the object with the smallest distance from the best options and the largest distance from the worst options. The method can be applied to both maximising indicators (whose best values are the largest) and minimising indicators (whose best values are minimum), i.e., there is no need to preliminarily transform minimisation indicators into maximisation ones. The TOPSIS method is popular and often used in practice. The normalisation of the TOPSIS method and the evaluation criteria use the distance between two points.

The TOPSIS method uses vector data normalisation (9).

$$\widetilde{r}_{ij} = \frac{r_{ij}}{\sqrt{\sum_{j=1}^{n} r_{ij}^2}}. \tag{9}$$

Here, r_{ij} is the evaluation of the *j*-th expert for the *i*-th alternative, (i = 1,. . ., m; j = 1,. . ., n), $\widetilde{r}_{ij}$ is the normalized value of the *i*-th indicator of the *j*-th object as determined by the TOPSIS method. Next, the best solution (variant) V^* (10) is preliminarily selected, i.e., we find the maximum value of each maximisation indicator (multiplied by the corresponding weights ω_i) and the minimum value of the minimisation indicator. The worst solution (variant) V^- (11) is also calculated.

$$V^* = \{V_1^*,\ V_2^*,\ \ldots,\ V_m^*\} = \left\{\left(max_j \omega_i \widetilde{r}_{ij}\ /\ i \in I_1\right),\ \left(min_j \omega_i \widetilde{r}_{ij}\ /\ i \in I_2\right)\right\} \tag{10}$$

$$V^- = \{V_1^-,\ V_2^-,\ \ldots,\ V_m^-\} = \left\{\left(min_j \omega_i \widetilde{r}_{ij}\ /\ i \in I_1\right),\ \left(max_j \omega_i \widetilde{r}_{ij}\ /\ i \in I_2\right)\right\} \tag{11}$$

Consequently, I_1 is the set of indices for the maximised indicators, I_2 is the set of indices for the minimised indicators, and ω_i is the weight of the *i*-th indicator. The essence of the method, the distances to the best and the worst solutions, i.e., the total distance D_j^* of each compared variant to the best solutions (variants) V^* (12) and the distance D_j^- to the worst solutions V^- (13). The evaluation criteria (distances) include the significance (weight) value ω_i of the relevant indicators, which affects the results.

$$D_j^* = \sqrt{\sum_{i=1}^{m} \left(\omega_i \widetilde{r}_{ij} - V_i^*\right)^2}. \tag{12}$$

$$D_j^- = \sqrt{\sum_{i=1}^{m} \left(\omega_i \widetilde{r}_{ij} - V_i^-\right)^2}. \tag{13}$$

The main criterion of the TOPSIS method C_j^* is calculated as the ratio of the distance to the worst solutions and the sum of the distances between the best and worst solutions (14), and the best solution (variant) corresponds to the highest value C_j^*.

$$C_j^* = \frac{D_j^-}{D_j^* + D_j^-},\ (j = 1,\ \ldots,\ n)\ \left(0 \le C_j^* \le 1\right). \tag{14}$$

Normalised data values are calculated (Table 8).

Table 8. Normalised r_{ij} values of calculation criteria $\widetilde{r}_{ij}$.

	Alternative Number, *i*									
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
Weight, ω_i / **Expert code, *j***	0.1091	0.0614	0.1023	0.1318	0.0955	0.1136	0.0614	0.1023	0.0977	0.1250
E1	0.137	0.082	0.110	0.110	0.055	0.137	0.027	0.082	0.110	0.082
E2	0.137	0.110	0.137	0.137	0.027	0.137	0.027	0.055	0.137	0.137
E3	0.137	0.082	0.110	0.137	0.082	0.137	0.082	0.082	0.137	0.110
E4	0.110	0.110	0.110	0.137	0.082	0.110	0.082	0.110	0.137	0.137
E5	0.055	0.055	0.110	0.137	0.137	0.137	0.137	0.137	0.137	0.137
E6	0.082	0.082	0.110	0.110	0.137	0.082	0.137	0.137	0.110	0.137
E7	0.082	0.082	0.082	0.110	0.137	0.055	0.137	0.137	0.110	0.110
E8	0.137	0.137	0.137	0.110	0.137	0.082	0.082	0.110	0.082	0.055

Source: Developed by authors based on survey data and calculations.

Next, it is necessary to calculate the weighted normalised values, because the TOPSIS method does not use normalized $\widetilde{r}_{ij}$ values, but rather uses weighted $\omega_i \widetilde{r}_{ij}$ values (Table 9).

Table 9. Weighted normalized values $\omega_i \widetilde{r}_{ij}$.

Expert Code, *j*	**Alternative Number, *i***									
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
E1	0.0149	0.0050	0.0112	0.0144	0.0052	0.0156	0.0017	0.0084	0.0107	0.0103
E2	0.0149	0.0067	0.0140	0.0180	0.0026	0.0156	0.0017	0.0056	0.0134	0.0171
E3	0.0149	0.0050	0.0112	0.0180	0.0078	0.0156	0.0050	0.0084	0.0134	0.0137
E4	0.0119	0.0067	0.0112	0.0180	0.0078	0.0124	0.0050	0.0112	0.0134	0.0171
E5	0.0060	0.0034	0.0112	0.0180	0.0131	0.0156	0.0084	0.0140	0.0134	0.0171
E6	0.0090	0.0050	0.0112	0.0144	0.0131	0.0093	0.0084	0.0140	0.0107	0.0171
E7	0.0090	0.0050	0.0084	0.0144	0.0131	0.0062	0.0084	0.0140	0.0107	0.0137
E8	0.0149	0.0084	0.0140	0.0144	0.0131	0.0093	0.0050	0.0112	0.0080	0.0068

Source: Developed by authors based on survey data and calculations.

With the weighted normalised values, it is possible to select the values of the best solutions (variants) V^* and the values of the worst solutions (variants) V^- (Table 10).

Table 10. Values of the best V^* and worst V^- variants.

Solutions (Options)	**Alternative Number, *i***									
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
V^*	0.015	0.008	0.014	0.018	0.013	0.016	0.008	0.014	0.013	0.017
V^-	0.006	0.003	0.008	0.014	0.003	0.006	0.002	0.006	0.008	0.007

Source: Developed by authors based on calculations.

After selecting the best and worst variants, the values of the partial criteria (distances) of the TOPSIS methods are calculated, that is, the distances to the best solutions D_j^* (12) and to the worst solutions D_j^- (13) (Table 11).

Table 11. Distances of individual experts' assessments to solutions D_j^* and D_j^-.

Solutions (Options)	Expert Code							
	E1	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**
D_j^*	0.0218	0.0219	0.0187	0.0177	0.0190	0.0180	0.0189	0.0204
D_j^-	0.0146	0.0190	0.0178	0.0177	0.0218	0.0193	0.0172	0.0174

Source: Developed by authors based on calculations.

Based on the data in Table 11, the values of C_j^* (14), the main criterion for evaluating the alternatives of the TOPSIS method, are calculated (Table 12).

Table 12. Values of the TOPSIS method criterion C_j^* and positions occupied by expert evaluations.

Criterion	Expert Code							
	E1	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**
C_j^*	0.4016	0.4646	0.4878	0.5003	0.5338	0.5179	0.4760	0.4608
Place	8	6	4	3	1	2	5	7

Source: Developed by authors based on calculations.

As can be seen in Table 12, the best solution of aspects and measures according to the TOPSIS method, by evaluating the weights of each measure, was accepted by expert E5, followed by experts E6 and E4. The evaluations of the selected experts are presented in Table 13.

Table 13. Evaluations of experts who took the highest places using the TOPSIS method.

Expert Code, *j*	Alternative Number, *i*									
	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
E5	*2*	2	4	*5*	5	*5*	5	5	*5*	5
E6	3	3	4	*4*	5	3	5	5	*4*	*5*
E4	*4*	4	*4*	*5*	3	*4*	3	4	*5*	*5*

Source: Developed by authors based on survey data.

After analysing the data collected from experts on the importance of each factor using the TOPSIS method, all data were normalised according to vector data normalisation, then, all assessments were weighted, including previously calculated factor weights. Since the main principle of the TOPSIS method is to select, from the compared objects, the object with the smallest distance from the best options and the largest distance from the worst options, the values of the best V^* and worst V^- options and the distances of individual experts' assessments to the solutions D_j^* and D_j^- were calculated. After evaluating these indicators, the values of the TOPSIS method criterion C_j^* and the places occupied by experts' evaluations were calculated. Here, we can also find the weights of each indicator (Table 14).

Table 14. Reorganised indicator weights and importance.

Indicator Number	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
Indicator weights, ω_i	0.072	0.072	0.096	0.112	0.104	0.096	0.104	0.112	0.112	0.12
Place	9–10	9–10	7–8	2–4	5–6	7–8	5–6	2–4	2–4	1

Source: Developed by the authors based on calculations.

It was found that the main factor of the aspects and measures according to this method is X10 (green client's assessment). It follows that banks should evaluate the green level of their clients. Other main factors are the following: X4, (innovations leading to a green economy), X8 (development of green financial products and services), X9 (green education/teaching).

5. Discussion

Rising concerns regarding rapid environmental degradation have brought increasing attention to the green concept at political, academic, and practical levels. The financial system has a mandate to lead the transformation to a green economy, and the banking sector should be at the forefront of this effort. Consequently, we suggest that the green performance of banks should be measured, as such monitoring will foster ecological well-being. The assessment of greenness often falls under the concept of ESG, where, in many cases, the social dimension is analysed more deeply [45].

Our results are in line with those who also highlight measures to create positive environmental effects, such as green innovations and practises, resource management, and emissions management, to evaluate the environmental measures of borrowers [23,46]. Our results support other findings of the articles referenced, as well as economic logic. The green criteria highly ranked by us in the 'client assessment' section are in line with the discussions regarding the implementation of credit ratings based on sustainable dimensions in the articles written by [46].

Our chosen method, TOPSIS, is widely used in similar studies [47–50]. The TOPSIS method is applied to each decision maker's weighted matrix of performances, resulting in a vector of alternatives with a ranking value. The vectors of all decision makers are then combined to generate a group matrix of performances. Determining the weight value calculated by the normalised matrix value requires a relatively better technique to obtain optimal results. Thus, the SMARTER method (Simple Multi-Attribute Rating Technique Exploiting Ranks) is used in the helpful weighting stage to obtain the optimal value. The SMARTER method can optimise the weighting value before proceeding to the next stage. This method is based on the theory that each alternative has several criteria with varying importance values and weights. The weighting in the SMARTER method uses a range between 0 and 1, thus facilitating the calculation and comparison of the values in each alternative.

The study was subject to several limitations.

1. Several methods of expert evaluation can be used to evaluate expert opinion, and similar results would likely be obtained, but the TOPSIS method is used for analysis, which is one of the simplest and most reliable methods used to evaluate expert opinion. It is possible that using a different method for analysis could cause the obtained results to be different, but here, the TOPSIS method was determined to be the most appropriate evaluation method. Using such a method, we follow the authors in assessing the performance of banks using TOPSIS methods [47–50].

2. The greater the number of experts interviewed, the more reliable the results are likely to be. In the article, eight experts are selected for the analysis because, based on the results of the literature analysis, this is the optimal number of experts needed to obtain reliable results. It is necessary to mention that the participating experts are persons that have worked in the banking sector for many years, and in everyday activity, their work is closely related to the fostering of sustainability.

3. Different factors/alternatives can be applied when analysing banking activities. Here, 10 groups of indicators were selected which best reflect the analysis topic.

The results of our study can provide useful information for regulators and managers to transform processes and expand knowledge about green performance in banking processes, as well as to avoid ecological simulation (green-washing). For future studies, the full methodology for formulating the index can be developed by evaluating various indicators according to the chosen criteria, following [51–53].

6. Conclusions

The assessment of the green performance of business units is carried out according to the strategy, the adjustment of goals, the definition and monitoring of sustainability indicators, and the submission of reports. In addition to traditional green transition activities, the banking sector plays a broader role by financing and investing in renewable energy and energy efficiency projects, offering environmentally friendly products and services, and working with stakeholders to promote the transition to a more sustainable green economy. The banking sector has played an important role in promoting the green development goals of the economy, both as an organization (e.g., by implementing various improvements) and by fulfilling its environmental responsibilities by integrating green lending practices into its decisions.

Based on a content analysis, we systemized a set of criteria that have been chosen for further evaluation by eight experts: management of resources (internal); waste management (internal); management of emissions (internal); innovations leading to a green economy; internal governance; external assessment; transparency; green financial products and services; green education/teaching; assessment of the greenness of clients.

Based on the results of the expert questionnaires, the concordance coefficient W = 0.18 was calculated, but based only on this concordance coefficient, it would be difficult to prove whether the opinions of the experts are aligned, since the number of indicators considered is more than seven, so the significance of the concordance coefficient was evaluated according to the $\chi 2$ Pearson criterion. If the significance level $\alpha = 0.05$ and the degree of freedom $\nu = 10 - 1 = 11$, the calculated critical value $\chi^2_{kr} = 16.92$, Pearson's criterion $\chi^2 = 29{,}697$, since the latter is greater than the critical value, is accepted, showing that experts' opinions are statically aligned. The authors argue that the TOPSIS method is very universal, and the results are clear and reliable. Based on Table 14, we can say that the most important is the 10th indicator, because all experts say that the weight of this indicator is the best. The highest significance was found to demonstrate the assessment of the green client. This result supports the economic logic of the green finance concept, and it follows that banks should evaluate the green level of their clients. In the case of other indicators, weights are very similar, and it is impossible to distinguish the three most important factors with greater weight. Other main factors are the innovations leading to a green economy, the development of green financial products and services, as well as green education/teaching.

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The Efficiency of Financing Environmental Protection Measures in the Context of Ukraine's Future Membership in the EU

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Abstract: In recent decades, humanity has had a significant negative impact on the environment. This problem can be solved only by establishing a rational environmental management policy and ensuring an effective financial policy in the context of balancing emissions and expenditures on environmental protection measures. The purpose of this article is to analyze the efficiency of financing environmental protection measures by determining the dependence of pollutant emissions on environmental protection expenditures in Ukraine and the European Union. The following methods were used for the study: analysis, synthesis, generalization, comparison, specification, and statistical and graphical methods. The statistical information was systematized on the basis of open data from the Open Budget web portal, the State Statistics Service, and Eurostat. This study identified the dynamics of revenues from environmental taxes in Ukraine; taxes on air emissions prevail. Most of the expenditures are made from the state budget. According to the functional classification, environmental expenditures are mainly aimed at preventing and eliminating environmental pollution. The dynamics of capital investments in environmental protection were also studied. To assess the effectiveness of the state policy in the field of environmental protection, we analyzed the dependence of pollutant emissions in Ukraine, Poland, and Romania on the amount of environmental expenditures and investments in this area and revenues from environmental tax. In Ukraine, the amount of pollutants released into the atmosphere depends mostly on investments in this area; in Poland—on revenues from environmental taxes; and in Romania—on expenditures on environmental protection. It has been established that the obtained models are adequate and can be used to build future forecasts of pollutant emissions. Directions for the development of financial and environmental policy are proposed. Post-war restoration of the environmental situation should be carried out on the basis of sustainable development, focusing on the European Green Deal A triple-task approach should be implemented, including environmental restoration, the minimization of negative climate change and balanced use of resources, and the expansion of powers of the relevant ministry with a focus on the strategic goals of the state policy. It is necessary to develop methodological recommendations according to international standards to assess the real state of the environment.

Keywords: environmental protection expenditures; environmental taxes; pollutant emissions; investments

1. Introduction

Globalization is having a significant impact on people's lifestyles [1]. It is transforming socio-economic forms of development within the existing natural resource and environmental conditions [2]. Globalization increases communication, accelerates access to technology

and innovation, and has ushered in an era of economic prosperity [1]. On the other hand, all of this has a negative impact on the environment and is a significant problem of the 21st century [3], provoking climate change, droughts, fires, etc. [4]. Environmental protection, the rational use of resources, and ensuring the ecological protection of human life are prerequisites for sustainable economic and social development of any country [5]. Ensuring ecological safety, namely the protection and restoration of the environment, is a priority task of the state and society [6]. One of the important areas of this sector is the alignment of financial flows with sustainable practices to achieve long-term climate and development goals [7]. The main directions of modern socio-environmental policy are the greening of social production and ensuring the environmental safety of the population and natural ecosystems [8]. The solution of environmental problems largely depends on the efficiency of the financial support system, the established composition and volume of funding sources, and the identified priority areas of their use, which requires a scientifically based analysis [9].

The object of this study is Ukraine, a developing country that is currently in the midst of military operations. It requires significant transformational changes in environmental policy and development strategy to address the environmental challenges it is currently facing. As Ukraine seeks to become a member of the EU and develop a course toward achieving the Sustainable Development Goals, it is important to assess the environmental component in comparison with other member states. We chose Poland and Romania as the countries bordering Ukraine and most closely related to environmental development.

In Ukraine, the main sources of public funding for environmental protection are currently the state and local budgets [1]. In the structure of environmental financing, the key place is occupied by environmental taxes and fees, the proceeds from which are used to protect the environment, minimize the negative impact of economic activity, and manage the rational use of natural resources [10]. At the same time, in the current system of regulation in the field of environmental management and environmental taxation in Ukraine, the existing levels of payments and fees are not able to ensure sustainable development in the accumulation of financial resources and the targeted allocation of funds for environmental activities [11]. Therefore, the implementation of successful foreign experience in this area to the Ukrainian economic space can yield positive results at the initial stages of reform [12].

Studies on environmental expenditures have been carried out by scholars such as Caglar A. E., Yavuz E. [4], Glukhova V., Kravchenko K. [5], Pirgaip B., Bayrakdar S., Kaya M. V. [7], Bukalo N. [8], Yaroshevych N. and Yakymiv A. [9], Karlin M., Prots N., Prots V. [10], Cherenkevych O. [11], Samko O. [12], and others. The trends of the green economy have been studied by Zhang L., Xu M., Chen H., Li Y., and Chen S. [1]. Despite the numerous studies, the issue of financing the environmental sector, including in Ukraine, remains quite relevant, especially now that society is facing global threats of climate change, ecosystem degradation, natural disasters, and human-made impacts.

The purpose of this article is to analyze the efficiency of financing environmental protection measures by determining the dependence of pollutant emissions on environmental protection expenditures in Ukraine and the European Union. The contribution of this study is that the proposed models can be used to build future forecasts of pollutant emissions and to develop state policy in the field of regulating environmental protection financing.

This paper consists of an introduction, materials and methods, results, a discussion, and conclusions. The Section 3 presents an analysis of the revenues from environmental taxes, environmental expenditures by budget and functional classification, and capital investment in environmental protection.

2. Materials and Methods

The main research period is 2015–2021. This time period allowed us to form an objective vision of the situation, since the statistics contain information on the temporarily occupied territories until 2014, and in 2022, due to the beginning of the full-scale invasion,

environmental protection expenditures decreased significantly due to objective factors and there is no information on the territories temporarily occupied after 24 February 2022. To understand the scale of the problem that currently exists in Ukraine, we have additionally displayed some indicators for 2022 and calculated projected indicators for 2023.

To form a statistical sample for the correlation and regression model, the time interval of 2015–2020 was chosen. Time periods before 2015 were not analyzed, as they contain somewhat outdated information and are incomparable due to the beginning of Russian aggression. Information about 2021 is not available in the statistics, and the figures for 2022 are incomparable due to the beginning of Russia's full-scale invasion, which has affected environmental policy as well. Therefore, it is illogical to use such data to determine certain patterns under optimal sustainable conditions, and the model is based on data for 2015–2020.

The statistical information was systematized on the basis of open data from the Open Budget web portal, the State Statistics Service, and Eurostat.

The following methods were used for this study: analysis, synthesis, generalization, comparison, specification, and statistical and graphical methods.

Using correlation and regression analyses, the influence of factors on the emissions of major pollutants into the atmosphere was assessed. Emissions of the main pollutants into the atmosphere are defined as a resultant feature. Expenditures, investments, and environmental tax revenues were chosen as the factor attributes. At the first stage, correlation matrices were constructed using the Microsoft Excel 2013 data block "Data Analysis" (the "Correlation" tool) to determine the correlation between the dependent and independent variables. The correlations range from -1 to +1, where -1 is a perfect negative correlation, 0 is no correlation, and +1 is a perfect positive correlation. Based on the results of the correlation analysis, the data with the highest level of correlation were selected for regression analysis.

Then, based on the formed sample, a regression analysis was conducted, which shows the contribution of the independent variable to the variation in the dependent variable under study. This analysis was conducted using the Microsoft Excel data block "Data Analysis" (the "Regression" tool). The regression analysis allowed us to estimate the size and direction of the relationship. As a result of the analysis, linear regressions were generated, which generally look like this:

$$y = b_0 + b_1 x_1, \quad (1)$$

y—dependent variable;
x—independent variable;
b_0, b_1—regression coefficients.
For Ukraine, the linear regression equation is as follows:

$$y = 4984.5 + (-6.8)x_1 \quad (2)$$

For Poland, the linear regression equation is as follows:

$$y = 450{,}013.0 + (-160.2)x_1 \quad (3)$$

For Romania, the linear regression equation is as follows:

$$y = 116{,}392.9 + (-11.5)x_1 \quad (4)$$

3. Results

Tax policy is a part of the government's toolkit to address environmental issues, including climate change. Environmental taxation can help reduce environmentally harmful behavior while generating revenue at all levels of government [13]. The national legislation emphasizes that the main purpose of establishing an environmental tax is to increase incentives for the rational use of natural resources [14].

In Ukraine, the environmental taxes include:

- An environmental tax levied on the emissions of pollutants into the atmosphere by stationary sources of pollution (except for emissions of carbon dioxide into the atmosphere);
- Revenues from pollutant disposals directly into water bodies;
- Revenues from waste disposal in specially designated places or facilities, except for the disposal of certain types of waste as secondary raw materials;
- An environmental tax levied on the generation of radioactive waste (including already accumulated waste) and/or the temporary storage of radioactive waste by its producers beyond the period established by the special conditions of licenses;
- An environmental tax levied on carbon dioxide emissions from stationary sources of pollution (Figure 1).

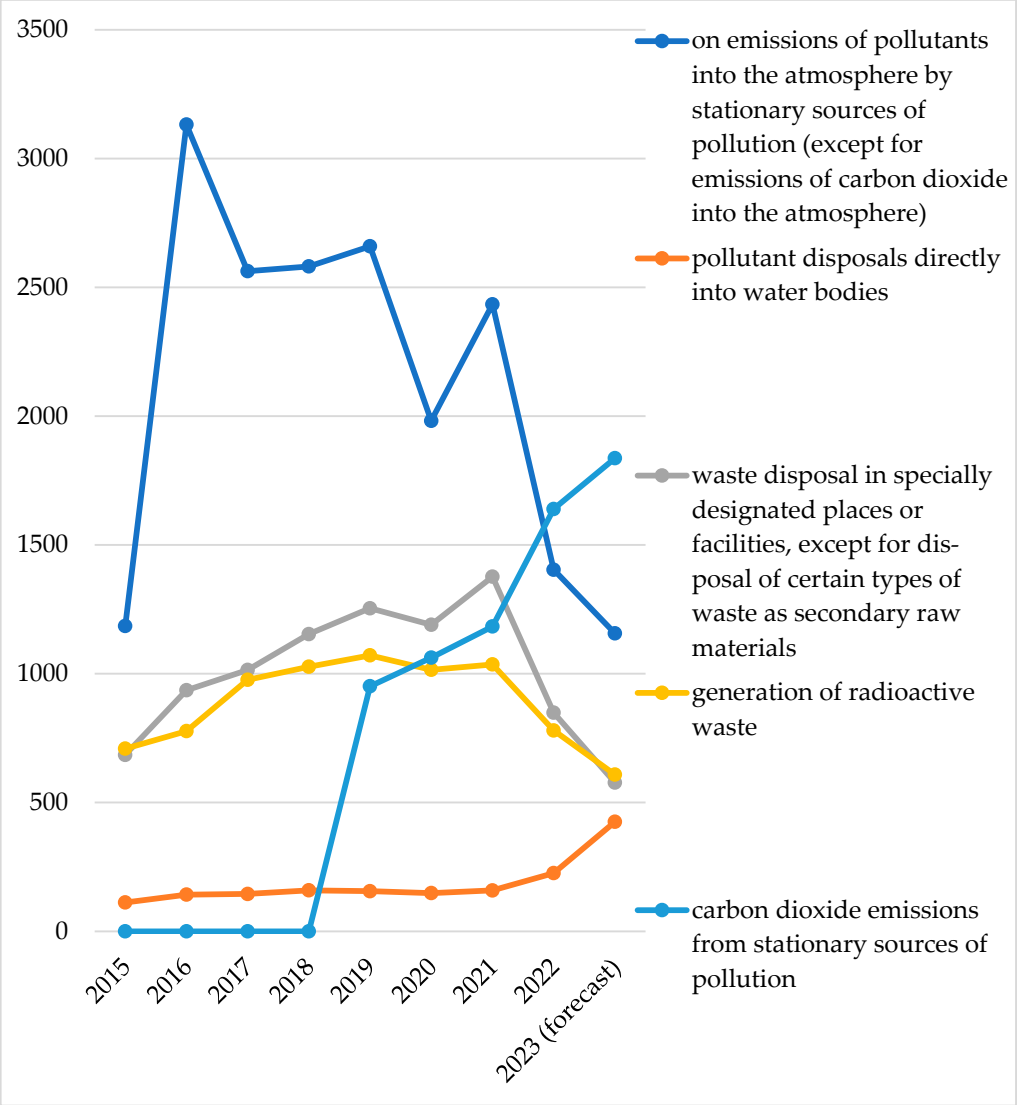

Figure 1. Revenues from environmental taxes (according to the consolidated budget of Ukraine, millions UAH). Source: based on data from [15].

As can be seen in Figure 1, taxes on air emissions account for the largest share of the total amount of environmental taxes. In total, in 2015–2023, including the taxes on carbon dioxide emissions, they amounted to 44.1%, 62.8%, 54.5%, 52.5%, 43.7%, 37.6%, 39.3%, 28.7%, and 25.1%, respectively. The share of taxes on emissions into water bodies was 5% in 2015–2022 and is projected to reach 9.2% in 2023. The maximum share of revenues from

the disposal of waste in specially designated places during 2015–2022 was 25.4% in 2015, and the (projected) minimum share was 12.5% in 2023.

The share of the environmental tax levied for the generation and/or storage of radioactive waste in the total amount of environmental taxes in 2015–2021 averaged 19.1%. From 2020 to 2023, the share is projected to decrease by 5.6%.

The share of the environmental tax levied on carbon dioxide emissions from stationary sources of pollution increased to 24.3% in 2019–2023.

The share of the environmental tax on carbon dioxide emissions increased from 15.6% to 39.9% in 2019–2023.

Revenues from the environmental tax on air emissions, excluding carbon dioxide, increased significantly in 2016 compared to 2015 (+164.2%), and then the amount of funds decreased by 18.2% and remained almost unchanged in 2018–2019. In 2020, compared to 2019, there was a decline of 25.5%, followed by an increase of 22.8% and a further significant chain reduction of 42.3%. In 2023, the decrease in revenues is projected to be 17.6%.

In 2016–2018 and in 2021, there were increases in the revenues from discharges into water bodies of 27.3%, 1.8%, 9.8%, and 7.1% compared to the previous years, respectively. Decreases in the revenues occurred in 2019 and 2020 (−2.1% and −4.9%, respectively). In 2022, there was a sharp increase compared to 2021 (+42.4%). Growth is also predicted for 2023 (+88.1%).

In 2015–2019, the total increase in revenues from waste disposal in designated areas was 67.5%. During 2019–2022, their value changed in waves: in 2019 and 2021, there were increases (+8.7% and 15.7%, respectively), and in 2020 and 2022, decreases (−5.1% and −38.4%, respectively). The decrease in these revenues in 2023 may amount to 32.0%.

The maximum decrease in revenues from the environmental tax levied on the generation and/or temporary storage of waste occurred in 2022 compared to 2021 (−24.7%). The maximum increase in revenues from the environmental tax levied on the generation and/or temporary storage of waste occurred in 2017 compared to 2016 (+25.6%).

Revenues from the environmental tax on carbon dioxide emissions are characterized by stable growth (+11.7% in 2020, +11.4% in 2021, +38.5% in 2022, and +12.0% in 2023 (forecast), compared to the previous periods).

While analyzing revenues from environmental taxes, it is important to examine the expenditure component as an instrument of a coherent environmental and fiscal policy. The expenditures on environmental protection include all expenditures on preventing, minimizing, or eliminating negative effects. Table 1 shows the environmental expenditures by type of budget and in total.

Table 1. Environmental protection expenditures in Ukraine.

Year	Local Budgets, Millions UAH		State Budget, Millions UAH		Consolidated Budget, Millions UAH	
	Total, Millions UAH	Per 1 Person, UAH	Total, Millions UAH	Per 1 Person, UAH	Total, Millions UAH	Per 1 Person, UAH
2015	1477	34	4053	95	5530	129
2016	1484	35	4772	112	6255	147
2017	2609	61	4740	112	7349	173
2018	3001	71	5241	124	8242	195
2019	3414	81	6316	151	9730	232
2020	3777	90	7433	178	11,211	268
2021	3266	78	9299	223	12,565	301
2022	513	14	4714	131	5227	145
2023 (prediction)	760		4437		5195	

Source: systematized according to [16].

In 2015–2021, the local environmental expenditures increased by UAH 1789 million (121.1%), while the state budget expenditures increased by UAH 5246 million (129.4%).

According to the consolidated budget, the expenditures increased by UAH 7035 million, which is 127.2%. For a more objective assessment, we analyzed these expenditures per capita, as it is important not only to increase expenditures in general, but to do so in proportion to the population. In 2015–2021, the expenditures per capita increased by UAH 172 (+133.3%), including UAH 128 (+134.7%) from the state budget and UAH 44.0 (+129.4%) from local budgets. That is, the expenditures per capita are growing at a higher rate than the total expenditures.

Let us take a closer look at 2022. The total expenditures on environmental protection decreased by UAH 7338 million (−58.4%) from UAH 12,565 million to UAH 5227 million, including UAH 4585 million (−49.3%) from the state budget and UAH 2753 million (−84.3%) from local budgets. The expenditures per capita decreased by UAH 156 (−51.8%); the state budget expenditures—by UAH 92 (−41.3%); and the local budgets—by UAH 64 (−82.1%).

Since the budget deficit is usually measured as a percentage of GDP, we set the following. The expenditures as a percentage of GDP according to the local budget in 2015–2021 amounted to 0.1%, and in 2022, this figure decreased. According to the state budget, the value averaged 0.2%, except for 2018 and 2022, when the figure was 0.1%. According to the consolidated budget, this value was 0.3% in 2015–2016 and 2020, and 0.2% in 2017–2019 and 2021; in 2022, the share decreased to 0.1%.

Next, let us analyze the environmental expenditures in more detail by the functional classification of expenditures (Figure 2 and Table 2).

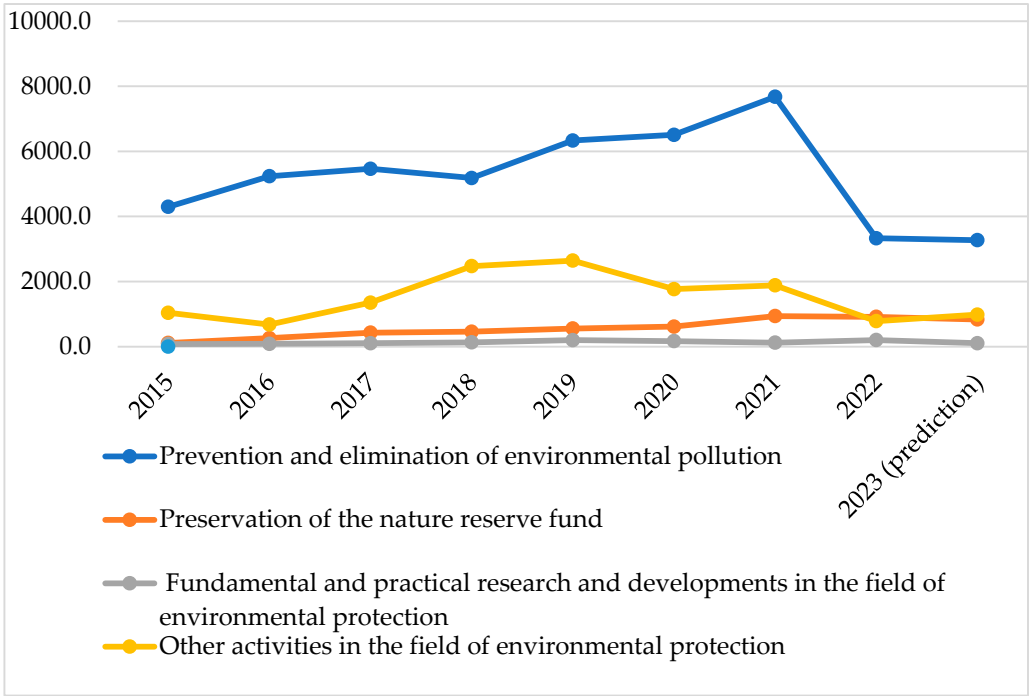

Figure 2. Ukraine's environmental protection expenditures by functional classification, millions UAH. Source: based on data from [17].

In 2015–2022, the largest share of environmental protection expenditures was allocated to prevent and eliminate environmental pollution. During 2015–2018, according to the state budget, their share decreased from 82.2% to 69.8%, and during 2018–2022, it increased from 69.8% to 81.6% (+11.8%); furthermore, there was a 14.9% decrease in expenditures (from 81.6% to 66.7%). According to the local budget indicators for 2018–2022, these expenditures decreased by 14.9%. During 2018–2021, in the consolidated budget, expenditures on the prevention and elimination of environmental pollution increased by 9.5%, and in 2022, decreased by 14.0% compared to 2021. The projected calculation for 2023 reflects an increase

of 2.9%. The bulk of expenditures were made at the expense of the state budget. During 2018–2021, there was an increase in the consolidated budget of 48.2%, including an increase in the state budget of 80.7% and a decrease in the local budget of 30.0%. In 2022, revenues to local budgets decreased by 82.6%, the state budget by 52.5%, and the consolidated budget by 56.7%.

Table 2. Expenditures on environmental protection in Ukraine by functional classification in terms of budgets, millions UAH.

Year	Prevention and Elimination of Environmental Pollution		Preservation of the Nature Reserve Fund		Fundamental and Practical Research and Developments in the Field of Environmental Protection		Other Activities in the Field of Environmental Protection	
	State	Local	State	Local	State	Local	State	Local
2015	3331.5	963,6	53.9	59.5	81.3		586.2	453.6
2016	4054.8	1179.8	209.6	49.7	84.8		422.5	254.4
2017	3651.1	1813.6	361.6	66.6	104.3		622.8	729.0
2018	3660.8	1519.4	420.0	39.1	130.4		1029.9	1442.2
2019	4774.1	1559.3	501.6	52.3	197.4		842.9	1801.7
2020	5416.0	1091.9	549.7	64.7	167.5		503.5	1263.1
2021	6616	1062.9	837.9	100.6	121		625.1	1256.7
2022	3143.8	184.7	857.8	56.4	202		510.3	271.3
2023 (prediction)	3087.8	184.8	782.9	50.5	105.1		458.8	524.4

Source: based on data from [17].

Expenditures on the conservation of the nature reserves from the state budget in 2015–2020 fluctuated in the range of 1.3–8.3%, increasing to 10.2% (+1.9%) in 2021 and to 18.2% (+8.0%) in 2022. These expenditures, at the expense of local budgets, are characterized by a gradual decrease from 4.0% in 2015 to 1.3% in 2018, and an increase from 1.3% to 11.0% (+9.7%) during 2018–2022. Also, during this period, the expenditures on the conservation of nature reserves increased by 104.2% in the state budget; by 44.2% in the local budget, and by 99.1% in the consolidated budget. In 2023, the above expenditures are expected to decrease.

Fundamental and practical research and development in the field of environmental protection is financed exclusively from the state budget and accounted for less than 5.0% in the period 2015–2022. The existing funding system should be reviewed, as research and development expenditures should also be financed from the local budget, taking into account the territorial specifics of practical testing of scientific research.

The expenditures on other environmental protection activities are largely financed from local budgets and accounted for 30.7–52.2% of the total expenditures in this area in 2015–2022. In the structure of state budget expenditures, their share decreased by 5.6% in 2016, increased by 4.2% in 2017 and by 6.6% in 2018 compared to the previous year, decreased to 7.6% by 2021, and increased to 10.8% in 2022. According to the consolidated budget, these expenditures increased by 7.0% in 2018–2019. This was due to a 24.9% increase in local expenditures and an 18.2% decrease in state expenditures. In 2020, the expenditures decreased by 33.2% in the consolidated budget, and in 2021, they increased by 6.5% compared to the previous period. In 2022, there was a 58.5% reduction in expenditures in general, including 18.4% from the state budget and 78.4% from the local budget. The forecast for 2023 shows an increase in expenditures by 25.8% overall.

An analysis of capital investment in environmental protection shows that in 2016, compared to 2015, it increased by 74.5%; in 2017–2018, it decreased by 17.7% and 8.6%, respectively; in 2019, it increased by 61.4%, followed by a decrease of 18.6% in 2020 and an

increase of 6.6% in 2021; in 2022, there was a significant decrease of 54.3%, followed by an increase of 28.5% in 2023 (Figure 3).

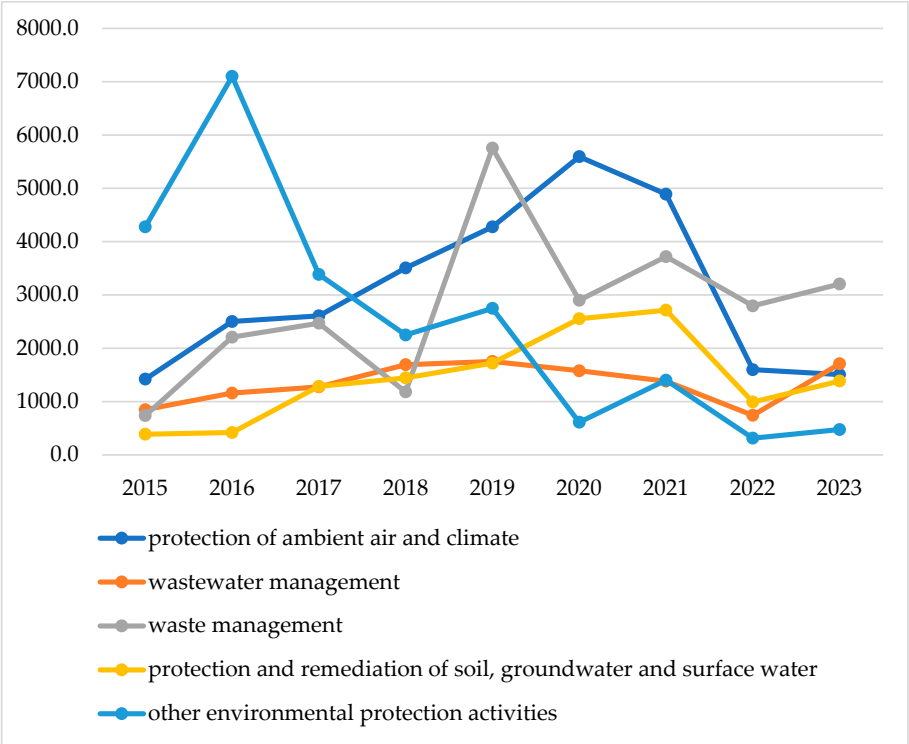

Figure 3. Capital investments in environmental protection, millions UAH). Source: based on data from [18].

The structure of investments in 2015–2017 was dominated by other measures, with shares of 55.7%, 53.0%, and 30.7%, respectively; in 2018, 2020–2021—by investments in air protection and climate change (34.8%, 42.3%, and 34.7%, respectively); in 2019, 2022–2023—by investments in waste management (35.4%, 43.4%, and 38.7%, respectively).

To assess the effectiveness of the state's policy in the field of environmental protection, we analyzed the dependence of pollutant emissions on the amount of environmental expenditures, investments in this area, and revenues from environmental tax. The atmospheric air and the costs and revenues associated with it were chosen to be the object of this study (Table 3). The reasonableness of this choice is confirmed by the official statistical data of Ukraine. In addition, it was determined that emissions into the atmosphere can be regulated depending on the activities of business entities and the population as a whole.

Table 3. Air pollutant emissions, expenditures and investments in air protection, and environmental tax revenues in Ukraine.

Year	Emissions of Major Pollutants into the Atmosphere, Thousands of Tons (y)	Expenditures on Air Protection, Millions EUR (x_1)	Investments in Air and Climate Protection, Millions EUR (x_2)	Revenues from the Environmental Tax Levied on Air Emissions, Millions EUR (x_3)
2015	4521.3	62.7	58.7	48.9
2016	4686.6	62.2	88.5	110.7
2017	4230.6	70.1	86.9	85.4
2018	4121.2	90.2	109.1	80.3
2019	4108.3	102.4	147.7	124.7
2020	3675.3	77.2	181.7	98.9
2021	4521.3	62.7	58.7	48.9

Source: systematized according to [15,18].

First, we tested the existence of a relationship between the dependent and independent variables (Table 4).

Table 4. Results of the correlation analysis.

	y	**x_1**	**x_2**	**x_3**
y	1			
x_1	−0.54587	1		
x_2	−0.86366	0.597439	1	
x_3	−0.22517	0.501104	0.620521	1

Source: calculated using Microsoft Excel.

The Chaddock scale was used to interpret the level of the interdependence. The results show that there is a high correlation between the performance indicator and x_2, a medium correlation between y and x_1, and a very close correlation between y and x_3. It is worth noting the existence of an inverse relationship between the performance attribute and all the factor attributes. For further analysis, we selected x_2 as the factor that has the greatest impact on air pollutant emissions (−0.86).

Furthermore, based on the regression analysis, the dependence of air pollutant emissions on investments in this area was determined (Table 5).

Table 5. Results of the regression analysis.

Indicator	**Value of x_2**
Multiple R	0.863664
R-square	0.745916
Normalized R-squared	0.682395
Standard error	199.6411
Observations	6

Source: calculated using Microsoft Excel.

The multiple correlation coefficient shows the total correlation between y and x_2 (0.863664) and indicates a strong relationship between the independent and dependent variables. The coefficient of determination is 0.745916 and shows the overall quality of the model and that the estimated parameters of the model are 74.6% explained by the dependence between the estimated parameters. The rest (25.4%) are inherent in factors not taken into account in the proposed model. The described indicators confirm the regularity of the studied dependence.

The results of the analysis of variance are presented in Table 6.

Table 6. Results of the analysis of variance.

	df	**SS**	**MS**	**F**	**Significance of F**
Regression	1	468,029.2	468,029.2	11.74283	0.026614
Balance	4	159,426.3	39,856.58		
Together	5	627,455.5			

Source: calculated using Microsoft Excel.

The adequacy of the model was confirmed by the Fisher's criterion. When comparing the observed Fisher's criterion with the tabulated one, it was found that, with a reliability coefficient of 0.95 and significance of the hypothesis of 0.05, the calculated value of F (11.74283) is greater than the tabulated value of 0.026614. And since the significance of F is less than 0.05, it can be argued that the model is adequate according to the Fisher criterion, with a reliability level of 0.95.

The existence of a connection within this model is confirmed by the correlation coefficients (Table 7).

Table 7. Table of coefficients.

	Ratios	Standard Error	t-Statistic	*p*-Value	Bottom 95%	Top 95%
Y-section	4984.504	236.4542	21.08021	2.99×10^{-5}	4328.002	5641.006
x_1	−6.78489	1.979959	−3.42678	0.026614	−12.2821	−1.28764

Source: calculated using Microsoft Excel.

From the table, the linear regression coefficients were determined: b_0 = 4984.504; b_1 = −6.78489. According to Student's criterion, the coefficient is statistically significant.

Based on the linear model, the predicted values in (Table 8) were determined.

Table 8. Projected emissions of pollutants into the atmosphere.

Year	Emissions of Major Pollutants into the Atmosphere, Thousands of Tons (y)	Investments in Air and Climate Protection, Millions EUR (x_2)	Emissions of Major Pollutants into the Atmosphere, Thousands of Tons (Predicted Value)
2015	4521.3	58.7	4586.0
2016	4686.6	88.5	4384.3
2017	4230.6	86.9	4394.8
2018	4121.2	109.1	4244.5
2019	4108.3	147.7	3982.2
2020	3675.3	181.7	3751.5

Source: calculated using Microsoft Excel according to [15,18].

The distribution of values on the normal distribution graph is narrow, which confirms the accuracy of the model (Figure 4).

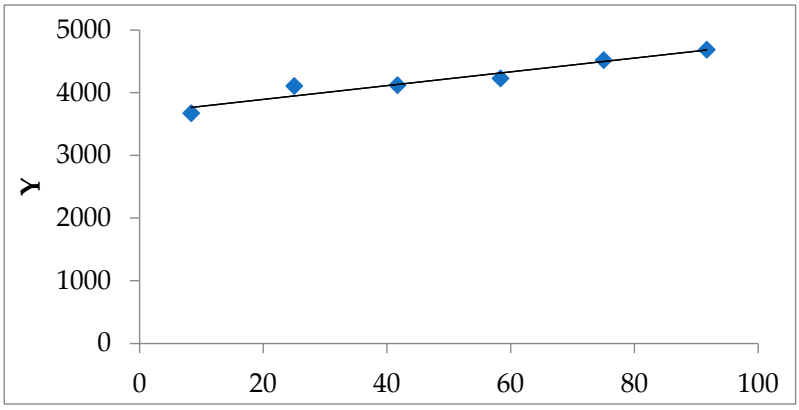

Figure 4. Graph of normal distribution. Source: built using Microsoft Excel.

This study found that the emissions of pollutants into the air are inversely proportional to the investments in this area: the higher the amount of investment, the lower the emissions.

As Ukraine aspires to become a member of the European Union, we believed it would be appropriate to conduct a similar analysis of the performance of individual EU member states. Poland and Romania, which are Ukraine's neighbors and cooperate with our country, were chosen for this stage of the study. In addition, these countries are characterized by different levels of economic and social development, which allows us to assess environmental policy in the presence of disproportionate environmental opportunities.

The data for the analysis of Poland's indicators are shown in Table 9.

At the first stage, as in the analysis of Ukraine's indicators, we checked the interconnection between the dependent and independent variables (Table 10).

Table 9. Air pollutant emissions, expenditures, investments in air protection, and revenues from pollution taxes in Poland.

Year	Emissions of Major Pollutants into the Atmosphere, Thousands of Tons (y)	Expenditures on Environmental Protection, Millions EUR (x_1)	Investments in Air Protection and Climate Protection, Millions EUR (x_2)	Revenues from Pollution Taxes, Millions EUR (x_3)
2015	340,984.2	1629.2	112.2	725.13
2016	352,343.1	1306.5	51.5	594.98
2017	368,592.5	1350.9	50.9	559.08
2018	367,225.1	1645.1	145.1	538.54
2019	350,689.0	1652.0	207.1	572.65
2020	334,791.2	1262.1	167.7	663.08

Source: systematized according to [19].

Table 10. Results of the correlation analysis.

	y	x_1	x_2	x_3
y	1			
x_1	0.174418	1		
x_2	−0.38216	0.483731	1	
x_3	−0.83934	−0.05232	0.051072	1

Source: calculated using Microsoft Excel.

Based on the Chaddock scale, the following was found. There is a weak relationship between the performance attribute and factor x_1; between y and x_2—a moderate inverse relationship; between y and x_3—a high inverse relationship. Further analysis was based on the indicators of the factor x_3.

The next step was to conduct a regression analysis (Table 11).

Table 11. Results of the regression analysis.

Indicator	Value of x_3
Multiple R	0.83934206
R-square	0.704495095
Normalized R-squared	0.630618868
Standard error	8267.839883
Observations	6

Source: calculated using Microsoft Excel.

The multiple correlation coefficient proves the existence of a strong relationship between the outcome and factor attributes. The coefficient of determination (R-square) shows that the model parameters are 70.4% explained by the dependence of y and x3. The determined indicators confirm the regularity of the studied dependence.

The results of the analysis of variance are shown in Table 12.

Table 12. Results of the analysis of variance.

	df	SS	MS	F	Significance of F
Regression	1	651,864,581.6	651,864,581.6	9.53615431	0.036643091
Balance	4	273,428,705.3	68,357,176.33		
Together	5	925,293,286.9			

Source: calculated using Microsoft Excel.

The analysis of Fisher's criterion shows significance of F = 0.036643091 < 0.05, which confirms the adequacy of the model. It should also be noted that, according to this criterion, the calculated value with a model reliability level of 95% is higher than the tabulated value.

The correlation coefficients are presented in Table 13.

Table 13. Table of coefficients.

	Ratios	Standard Error	t-Statistic	*p*-Value	Bottom 95%	Top 95%
Y-section	450,013.033	31,777.3782	14.1614274	0.00014435	361,784.89	538,241.179
x_1	−160.2462	51.89208442	−3.08806644	0.03664309	−304.3217	−16.170680

Source: calculated using Microsoft Excel.

The following linear regression coefficients were obtained: b_0 = 450,013.033; b_1 = −160.2462. The test by Student's criterion showed the statistical significance of b_0 and b_1.

The calculated values of the pollutant emissions are shown in Table 14.

Table 14. Projected emissions of pollutants into the atmosphere.

Year	Emissions of Major Pollutants into the Atmosphere, Thousands of Tons (y)	Revenues from Pollution Taxes, Millions EUR (x_3)	Emissions of Major Pollutants into the Atmosphere, Thousands of Tons (Predicted Value)
2015	340,984.2	725.13	333,813.7
2016	352,343.1	594.98	354,669.7
2017	368,592.5	559.08	360,422.6
2018	367,225.1	538.54	363,714.0
2019	350,689.0	572.65	358,248.0
2020	334,791.2	663.08	343,757.0

Source: calculated using Microsoft Excel according to [19].

The accuracy of the model is confirmed by a normal distribution graph with a narrow distribution of values (Figure 5).

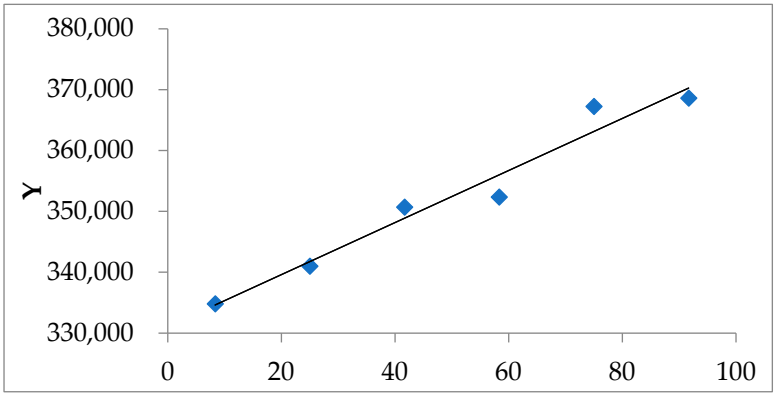

Figure 5. Graph of the normal distribution. Source: built using Microsoft Excel.

Romania was chosen as another country for comparative analysis. The initial information for the calculations is presented in Table 15.

Table 15. Air pollutant emissions, expenditures, investments in air protection, and revenues from pollution taxes in Romania.

Year	Emissions of Major Pollutants into the Atmosphere, Thousands of Tons (y)	Expenditures on Environmental Protection, Millions EUR (x_1)	Investments in Air Protection and Climate Protection, Millions EUR (x_2)	Revenues from Pollution Taxes, Millions EUR (x_3)
2015	104,264.8	1111.2	104.6	8.21
2016	100,113.4	1261.2	18.3	10.47
2017	102,233.3	1220.4	6.9	9.78
2018	102,372.8	1255.9	4.7	9.45
2019	98,747.1	1688.3	4.9	8.85
2020	94,137.7	1823.2	6.2	9.14

Source: systematized according to [19].

The results of the correlation analysis for Romania are shown in Table 16.

Table 16. Results of the correlation analysis.

	y	**x_1**	**x_2**	**x_3**
y	1			
x_1	−0.931071536	1		
x_2	0.544238461	−0.517229923	1	
x_3	−0.115870636	−0.135166097	−0.609250925	1

Source: calculated using Microsoft Excel.

According to the Chaddock scale, there is a close relationship with factor x_1, a significant relationship with factor x_2, and a weak relationship with factor x_3. Also, the results of the correlation analysis show a direct relationship with factor x_2 and an inverse relationship with factors x_1 and x_3. For the regression analysis, factor x_1 was chosen, which has the greatest impact on y. The results are presented in Table 17.

Table 17. Results of the regression analysis.

Indicator	**Value of x_1**
Multiple R	0.931071536
R-square	0.866894204
Normalized R-squared	0.833617755
Standard error	1461.320607
Observations	6

Source: calculated using Microsoft Excel.

The total correlation between y and x_1 according to the correlation coefficient is 0.931071536, which confirms the existence of a strong relationship between the variables. According to the R-squared data, it was determined that the estimated model parameters are 86.7% explained by the outcome and factor attributes; 13.3% are accounted for by other factors.

The next step was to conduct an analysis of variance (Table 18).

Table 18. Results of the analysis of variance.

	df	**SS**	**MS**	**F**	**Significance of F**
Regression	1	55,631,419.56	55,631,419.56	26.0512835	0.006962956
Balance	4	8,541,831.664	2,135,457.916		
Together	5	64,173,251.23			

Source: calculated using Microsoft Excel.

A comparison of the calculated and tabulated values by Fisher's criterion showed that the model is adequate, since 26.0512835 > 0.006962956 and 0.006962956 < 0.05, with a reliability coefficient of 95% and a hypothesis significance of 5%.

The calculated correlation coefficients are shown in Table 19.

Table 19. Table of coefficients.

	Ratios	**Standard Error**	**t-Statistic**	***p*-Value**	**Bottom 95%**	**Top 95%**
Y-section	116,392.9	3206.693	36.29686	3.44×10^{-6}	107,489.7	125,296.1
x_1	−11.5414	2.261221	−5.10405	0.006963	−17.8195	−5.26322

Source: calculated using Microsoft Excel.

The following linear regression coefficients were obtained: b_0 = 116,392.9; b_1 = −11.5414. Student's criterion confirmed the statistical significance of the coefficients.

Based on the linear model, the predicted values in Table 20 were determined.

Table 20. Projected emissions of pollutants into the atmosphere.

Year	Emissions of Major Pollutants into the Atmosphere, Thousands of Tons (y)	Expenditures on Environmental Protection, Millions EUR (x_3)	Emissions of Major Pollutants into the Atmosphere, Thousands of Tons (Predicted Value)
2015	104,264.8	1111.2	103,568.1
2016	100,113.4	1261.2	101,836.9
2017	102,233.3	1220.4	102,307.8
2018	102,372.8	1255.9	101,898.1
2019	98,747.1	1688.3	96,907.6
2020	94,137.7	1823.2	95,350.6

Source: calculated using Microsoft Excel according to [19].

The narrow distribution of values on the normal distribution graph proves the accuracy of the model (Figure 6).

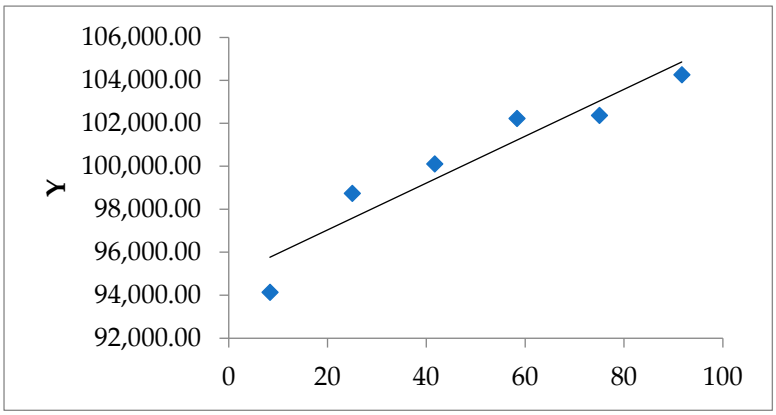

Figure 6. Graph of normal distribution. Source: built using Microsoft Excel.

4. Discussion

We agree with the position of Babichenko V., Glukhova V., and Kravchenko K., who noted that to ensure sustainable development, it is necessary to maintain a rational balance between the resources used by humanity and the problems that arise in the process of their use. Therefore, it is important to find ways to compensate for the damage caused. The need for greater efficiency of environmental measures and increased sources for their financing indicate the insufficient stability of the environment [3].

Scholars such as Bredikhina V. [20], Vitovska I. [21], and Poyasnik G. [22] have emphasized the importance of public administration in the field of environmental policy regulation. The use of various economic and legal instruments in the field of regulation of environmental relations is inextricably linked to environmental management, the success and effectiveness of which is determined by the effectiveness of measures to protect the environment and preserve natural resources and ecosystems [20]. In modern conditions, it is important to achieve effective coherence and the cooperation of all institutions responsible for the management and coordination of measures for the protection and rational use of natural resources of Ukraine [21]. The role of public environmental management is crucial in addressing the complex problems caused by human activity and climate change. However, global instability complicates the effective conduct of environmental management [22].

An indisputable argument was made by Yashkina V. [23], emphasizing that understanding the various sources and instruments of financing for adaptational measures based on an ecosystemic and nature-oriented approach will contribute not only to the creation of an effective and balanced portfolio of climate finance for climate change adaptation but also the development of a new method of forming a national budget aimed at mitigating and adapting to climate change [23].

We fully agree with the position of Babichenko V. and Glukhova V., who argued that the issue of financial support for environmental protection in modern conditions is defined as one of the most important, since it should not only cover the damage caused to the environment but also contribute to the restoration of natural resources and ensure the sustainable environmentally friendly development of society [3].

It is worth noting that, currently, the funding of environmental protection expenditures is very insufficient. Yaroshevych N. and Yakymiv A. have taken a similar position, stating that the financing of environmental protection from the budget is insufficient and needs to be increased [9]. Constant changes in the structure and powers of the central executive body responsible for the formation and implementation of state policy in the field of environmental protection, as well as significant fluctuations in the structure of state budget expenditures on environmental protection and in the structure of financing of targeted budget "environmental" programs indicate inconsistency in the priorities of the state's environmental policy.

Kovshun N. and Pyatki N. also argued that in Ukraine, the focus on budgetary resources for the financial support of environmental protection measures is unpromising. Additionally, enterprises implement environmental protection measures only if it is economically beneficial for them. At the same time, in order to fulfil Ukraine's international obligations in the field of environmental protection, companies that need to bring their operations to high European standards, which requires significant expenditures, expect the state to help them. This is why it is advisable to develop appropriate means of economic incentives and their legislative consolidation, which would make it possible to solve the problem of financial support for environmental protection by diversifying the sources of funding [24].

5. Conclusions

The main challenges in the field of environmental finance are insufficient funding, limited financial resources, and changes in the ratio of environmental tax distribution, which lead to a low efficiency of using funds for environmental protection measures [5].

The ability of Ukraine to provide financial support for the implementation of the environmental management strategy will largely depend on what steps can be taken within the existing organizational and legal structure for financing environmental activities. Therefore, understanding this structure is an important step in developing the necessary economic mechanisms to support and implement a strategy for the rational use of natural resources [25].

Ensuring a balanced ecological and economic development at different levels of economic activity is possible by achieving economic efficiency in financing environmental protection measures. In particular, the introduction of a methodology for assessing the effectiveness of air purification measures at the level of enterprise will allow for evaluating and balancing costs and benefits [11].

The results of the correlation and regression analyses show that Ukraine's financial and environmental policies are not effective enough. This is due to the irrational interrelation of pollutant emissions and the funds invested in this area and the solution of these problems. In this study, it was found that the obtained models are adequate and can be used to build future predictions of pollutant emissions.

Based on the analysis of the current financial and environmental policies, taking into account the situation in Ukraine after the beginning of the full-scale invasion of the Russian Federation, the trends in the EU countries, the study of the legislative framework, regulations, and the works of scholars and practitioners, we propose the following directions for the development of financial and environmental policies:

- The post-war restoration of the environmental situation should be carried out on the basis of sustainable development, focusing on the European Green Deal;
- The triple objective should be implemented: environmental restoration, minimization of negative climate change, and balanced use of resources;

- The powers of the relevant ministry should be expanded, with a focus on the strategic goals of state policy in this area in order to strengthen cooperation with international institutions in solving environmental problems;
- Methodological recommendations should be developed in accordance with international standards for assessing the real state of the environment coupled with its financial interpretation;
- A fundamental reform of the system of allocating funds for environmental purposes should be carried out by means of identifying specific priority areas and setting clear restrictions on the direction of funds;
- State and local budgets should provide funds for environmental protection measures based on the real needs of each individual region.

Implementation of the proposed measures will allow Ukraine to accelerate its progress toward achieving the Sustainable Development Goals, address current environmental issues, and develop strategies for at least 3–5 years. Taking these steps will also allow Ukraine to follow a common course with the EU and, accordingly, develop environment policies, and find ways to use resources in a balanced way.

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Does Firm Size Matter for ESG Risk? Cross-Sectional Evidence from the Banking Industry

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Abstract: The ambiguous evidence regarding the linkages between firm size and ESG risk in the relevant literature justifies the need for their further scientific investigation. A particularly interesting context for this task is offered by the banking industry, where financial institutions face both strong incentives to expand the scale of their activities and high reputational risk sensitivity. Given the above, this paper aims to systematize and enhance the theoretical underpinnings of the relationship between firm size and ESG risk in banks, highlighting its likely non-linear character, and to investigate it empirically in the cross-section of the international banking industry. This research employs uni- and multivariate, and linear and non-linear regression analyses applied to a sample of 668 banks that were assigned the Morningstar Sustainalytics ESG Risk Rating for the year 2021. The results demonstrate that, although, on average, size seems to be associated negatively with ESG risk in the cross-section, the relationship is in fact non-linear and follows a U-shaped pattern. The findings are robust regarding the impact of both country-specific contextual factors and outliers. This study emphasizes the importance of diseconomies of scale in ESG risk management, thus offering some important lessons and recommendations for bank executives and equity investors.

Keywords: ESG risk; ESG risk management; firm size; banks; banking services; multifactor regression analysis; non-linearities; diseconomies of scale

1. Introduction

With increasing global awareness of the importance of sustainability and social responsibility in business practices, companies around the world are continuously pressured to recognize and properly manage the relevant environmental, social, and governance (ESG) dimensions of their everyday actions and decisions. In fact, this pressure comes from every major stakeholder group, including customers, suppliers, employees, regulators, and, ultimately, investors.

As more and more professional asset managers representing the world's largest investment institutions integrate sustainability issues into their investment criteria [1,2] it seems that, after half a century, the classic Milton Friedman doctrine reducing the social responsibility of companies in profit maximization [3] is becoming outdated. The global interest in responsible investing is constantly gaining pace, as only in the last decade, the number of signatories to the UN-backed Principles for Responsible Investment, and the volume of assets under their management, more than tripled, reaching 3800 and USD 121.3 trillion, respectively [4]. Furthermore, benefits arising from ESG-based investing may extend to global financial stability frameworks, as they likely contribute to reductions in systemic risk [5]. Not surprisingly, therefore, the above tendencies stimulate the demand for both high-quality information disclosures regarding ESG risk exposures and the independent, comprehensive evaluation of companies' performance in the area of managing those risks. Over the last few decades, many leading rating and news agencies worldwide have developed unique methodologies designed to assess the overall ESG performance of business entities, with the purpose of providing market participants with comprehensive and easily interpretable measures in the form of dedicated ratings and scores [6].

Given the multitude of potential investment opportunities and the complexity of factors driving corporate ESG risk exposures, the vast majority of investors seem unable to efficiently analyse and evaluate the sustainability performance of companies on their own, and hence, may be forced to rely on the ready products of professional rating agencies [7].

The issues of social responsibility, sustainability, and ESG performance are also becoming increasingly important for firms operating in the financial industry, especially for banks, whose very existence and core business activities are crucially dependent on reputability and public trust. Not surprisingly, therefore, a dynamically growing amount of evidence in the relevant literature documents the increasing awareness of the need to incorporate ESG dimensions into banks' strategies, processes, and even specific products to meet stakeholders' expectations and promote value creation [8].

In fact, a substantially higher reputational risk exposure and vulnerability of banks to criticism from key stakeholder groups [9] should naturally give them even stronger motivation to engage in socially responsible activities and mitigate ESG risks than in the case of other industries. Moreover, banks' ESG risk is gaining additional importance from the perspective of their pivotal functions in the global financial system. The responsibility of banks as the world's leading financial intermediaries extends far beyond the individual interests of their owners, and in fact, may be perceived even from the standpoint of society as a whole due to their participation in the processes of the accumulation and allocation of capital, as well as their crucial role in the global financial stability framework [10]. The proper identification, management, and mitigation of ESG risks is vital, not only from the standpoint of individual banks' responsibility for the security of collected deposits, but also, given the typically large size and interconnectedness of their business activity, for the stability of the entire financial system they are part of.

Banks appear, however, to be slower in responding to ESG-related challenges than non-financial enterprises [11]. Furthermore, it seems that the principles of corporate social responsibility were not actually followed in the everyday business practices of many banks until the outbreak of the global financial crisis in 2008, and the resulting shift in their strategies and business models towards a broader and deeper incorporation of ESG concerns might be, to a large extent, an attempt to restore the sector's damaged reputation [10]. With the passing of time, however, banks seem to increasingly appreciate the benefits of ESG frameworks as a useful tool for the mitigation of operational [12,13] and credit [14] risk, reductions in the cost of equity [15,16] and liabilities [17,18], and ultimately, an important driver of their overall financial performance [19–21].

On the other hand, however, as highlighted by Finger et al. [22], the implementation of socially responsible practices by banks operating in different economic settings may serve completely different purposes. They report that, in developed countries, the adoption of the Equator Principles (EPs) [23] by banks results in increased funding activity and the growing share of interest income, whereas in developing ones, the effects are exactly the opposite. Hence, it appears that, for banks operating in developing countries, the adoption of EPs leads to profound changes in their realised market strategies, while for their counterparts from developed countries, it may merely be a form of "greenwashing".

Although ESG risk is likely determined by a wide array of economic, social, and environmental factors in the case of banks, one of them—i.e., the company size—seems particularly interesting and worth being investigated. Overall, the specificity of the banking industry creates strong incentives for increasing the size of business activity, resulting not only from substantial economies of scale and scope, but also from additional competitive advantages and economic benefits arising from the "too big to fail" (TBTF) status assigned to the largest, systemically important institutions. On the one hand, larger banks may be expected to outperform smaller ones in the area of ESG challenges, as they are usually able to engage more resources and sophisticated knowledge-based management tools to address related concerns. They are also typically under more pressure from equity investors, regulators, and other major stakeholder groups to comply with ESG principles in order to legitimize their strategies and business decisions. On the other hand, however,

as banks grow larger, their overall ESG risk exposure also builds up due to more numerous and more complex interactions with their external and internal stakeholders. Moreover, they also become more exposed to various inefficiencies and diseconomies of scale that likely impede their ability to properly identify, manage, and mitigate ESG risks.

The apparent two-way impact of size on bank ESG risk makes the relationship between them ambiguous and, therefore, worthy of scientific exploration. Perhaps surprisingly, to the best of the author's knowledge, no prior study has directly examined the above issue empirically. The related studies in the banking industry typically focus on the linkages between ESG performance and other dimensions of banking activity, including financial performance and risk or their mutual associations, and employ bank size merely as a control variable. Additionally, their findings with respect to the impact of size on bank ESG performance seem quite ambiguous. Also, the existing evidence for non-financial enterprises appears relatively modest and equally mixed. Given the above, the present study intends to fill the identified gap in the relevant literature.

The aim of the present paper is twofold. First, it attempts to systematize and enhance the theoretical underpinnings of the relationship between firm size and ESG risk in the specific context of the banking industry, highlighting the likely non-linear character of the association. Second, this study intends to empirically investigate the size–ESG risk nexus in the cross-section of the international banking industry. Using both uni- and multivariate, and linear and non-linear regression analyses applied to a sample of 668 banking companies that were assigned the Morningstar Sustainalytics ESG Risk Rating for the year 2021, this research demonstrates that, although size is, on average, associated negatively with ESG risk in the cross-section, the relationship is, in fact, non-linear, and follows a U-shaped pattern. The above findings hold after controlling for the impact of both country-specific contextual factors and outliers.

On the one hand, the findings of this paper appear to be in line with the slack resources hypothesis [24], as well as the stakeholder [25] and corporate legitimacy theories [26], and are largely consistent with the results of prior studies exploring the linkages between company size and ESG performance in both non-financial and financial sectors [7,18,24,26–37]. On the other hand, however, the convexity of the investigated relationship demonstrated in this study suggests the presence of non-negligible diseconomies of scale and efficiency challenges capable of partially offsetting the benefits of a greater availability of resources and higher-quality ESG risk reporting in larger banks [24,38]. Given the above, the present paper also contributes to the strand of literature highlighting the complexity and vagueness of the linkages between size, risk exposure, and ESG performance in the banking sector [39–45]. In addition, by emphasizing the importance of diseconomies of scale in ESG risk management, this manuscript offers some important lessons and recommendations for bank executives and equity investors.

The remainder of the paper is structured as follows: The next section provides a review of the relevant literature on the linkages between firm size, ESG performance, and risk in the contexts of both non-financial sectors and the banking industry. Section 3 outlines the details of the adopted research design, including hypothesis development, the methodological framework, and data collection procedures. The empirical results of this research are presented in Section 4, whereas Section 5 discusses them in the context of prior evidence in the relevant literature. The paper is closed with conclusions summarizing its main findings, key contributions, and their practical relevance.

2. Literature Review

2.1. ESG Performance, Risk, and Firm Size–Evidence from the Non-Financial Sector

Despite the initial scepticism from both practitioners and academics [3], over the last few decades, the ideas of corporate social responsibility (CSR) and socially responsible investing (SRI) have become increasingly important determinants of the capital allocation decisions of equity investors and asset managers around the world. Simultaneously, the perception of CSR has gradually evolved from its original, largely ethical, focus [46] towards

a recognition of its substantial economic potential as a tool supporting the management of environmental, social, and governance (ESG) risks, long-term financial performance, and, ultimately, value creation. The assessment of listed companies' exposures to ESG risks and their ability to manage those risks is therefore continuously attracting ever more attention from various internal and external stakeholders, including investors, managers, employees, business partners, and regulatory authorities [10]. In fact, since the beginning of the 21st century, the increased focus on the issues of corporate governance and sustainability has led to a gradual reorientation of the entire SRI concept towards ESG investing [47].

The evaluation of corporate ESG risk is crucially dependent on the availability and quality of relevant information. According to the organisational legitimacy theory, companies may be motivated to voluntarily disclose ESG-related information to comply with the expectations of their major stakeholders, and thus obtain a sort of "licence to operate" [26]. Many studies in the relevant literature demonstrate that the disclosure of ESG-related information may also be driven by expectations of economic benefits. Under this view, the provision of such information becomes a strategic investment aimed at the improvement of a company's reputation, perceived as a specific intangible asset [48–52]. In fact, as demonstrated by Pérez [53], the rapidly growing popularity of sustainability reports may directly reflect their application as tools for improving corporate reputation. The ultimate effects of such reporting activities are, however, conditional on the quantity and quality of obtainable data and the overall management of corporate transparency.

Good reputation creates a "cushion" against unfavourable market developments and allows firms to gain a sustained competitive advantage over less-reputable competitors [51]. Additionally, it may allow firms to improve their financial performance [51,54], reduce cost of debt [55], mitigate risk [15,16,56], and ultimately, increase their market value [50,57,58]. Not surprisingly, therefore, over the last few decades, the vast majority of empirical evidence documents a positive relationship between corporate ESG and financial performance [59]. Interestingly, recent evidence from the Chinese market provided by Pu [60] reveals a positive, yet curvilinear association between firm financial performance and ESG activities. The findings indicate that the relationship takes a form of an inverted U-shaped curve, suggesting that an excessive allocation of companies' resources and organizational efforts to ESG activities might be detrimental to their financial performance.

Apart from voluntary disclosures, the rapid expansion of ESG reporting is also stimulated by the requirements imposed by regulators worldwide [61–63]. Hence, contemporary corporate communication of ESG information often takes the form of comprehensive sustainability reports containing both voluntary and mandatory disclosures [64].

Given the countless different investment opportunities, as well as the time-consuming and operationally demanding nature of ESG risk evaluation processes, the above tendencies have also stimulated the demand for comprehensive, standardised methodologies for the assessment of companies' ESG performance. Consequently, numerous rating and news agencies around the world have developed dedicated scoring procedures to provide equity investors and other corporate stakeholders with comprehensive and easily interpretable measures of ESG performance and risk exposure [6]. Moreover, as the growing awareness of the climate change risk has increased the demand for ESG data and research even further, the world-leading providers of decision support tools for equity investors, including Dow Jones, Goldman Sachs, or MSCI, also began offering their own solutions, aiming to satisfy the growing demand from their largest clients [47].

Although there appears to be some progress in the standardisation of ESG performance and risk assessment in recent years, especially when compared with early approaches to CSP evaluation [65], the overall correlation between corporate ESG scores issued by different providers remains relatively low [66,67]. On the other hand, however, as pointed out by Cohen [68], firms are becoming increasingly aware of sustainability issues and continuously allocate their resources to mitigate the related risks, which leads to an overall improvement in their ESG scores.

Among many factors that shape a company's exposure to ESG-related risks, as well as its ability to mitigate them, a key role is undoubtedly played by its size. On the one hand, the scale of a company's operations drives the extent and complexity of its direct and indirect interactions with stakeholders and the environment. On the other hand, size largely determines the availability of the human, capital, and organizational resources needed to manage and report ESG risks. Larger firms are also more visible and scrutinised by various stakeholders, which encourages them to improve their sustainability performance, ESG risk management, and the quality of the related information disclosures.

The linkages between a company's size and ESG risk can be explored from the perspective of the slack resources hypothesis [24]. Under it, investments in initiatives with potentially delayed pay-offs [69] or of a lower priority [70], such as CSR, are strongly conditional on the availability of financial and human capital and the overall financial position of a company. From this point of view, larger and financially sounder firms are typically more capable of employing additional resources and formal instruments to analyse and disclose information on the ESG-related aspects of their activities. Given the substantial costs involved in ESG reporting [71], it comes as no surprise that the proneness to disclose voluntary ESG information usually increases with size [33]. Accordingly, ESG-related expenditure also tends to be positively related to both the size and profitability of companies [30]. As demonstrated by Orlitzky [72], however, firm size does not confound a usually positive relationship between social and financial performance reported in many studies.

Other studies explore the impact of firms' size on the associations between their ESG performance and risk. For instance, He et al. [73] report that better ESG performance enables firms to reduce risk by alleviating their financial constraints. The relative magnitude of the inhibitory impact of sustainability performance on firm risk may, however, vary with size. In turn, Cohen [68] examines the data for S&P 500 companies over the period of 2019–2021 to find that corporate financial stability, as proxied by the Altman Z-score, is likely weakened by high environmental and social risks. Additionally, he reports a particularly high sensitivity of the score to social risks in the subsample of smaller companies.

Although larger firms seem naturally more capable and prone to engage in ESG-related initiatives, empirical evidence provided by Baumann-Pauly et al. [29] demonstrates that they actually tend to focus primarily on communication and reporting socially responsible activities without implementing them substantially in their business practices.

Large firms are also more likely to take advantage of economies of scale with respect to the ESG challenges they face [74]. They often possess superior knowledge about sustainability management tools and more formalised ESR reporting structures compared to smaller firms [31]. In turn, smaller entities, usually being subject to greater competitive pressures, are less inclined to follow similar patterns [75].

Given the above, the ability to designate more resources to ESG activities and the disclosure of related information, combined with knowledge-based competitive advantages, render larger firms more legitimate to obtain higher marks from ESG rating agencies [7].

Furthermore, from the standpoint of the stakeholder theory [25], larger firms usually function under higher public pressure, given the more numerous and diversified stakeholder groups involved in their operations. Since they interact with a greater number and variety of stakeholders, their sustainability policies and related instruments are often more complex and multidimensional than in the case of smaller businesses [76]. Larger companies may therefore be motivated to disclose more relevant, comprehensive, and transparent ESG information in order to justify the legitimacy of their actions and business decisions [24,26,27]. Some studies, however, do not find any clear link between company size and their quality of sustainability reporting [77]. Empirical evidence supporting the stakeholder theory can be found in the recent research by Bissoondoyal-Bheenick et al. [78]. Using a sample of all companies with ESG scores from G20 countries over the period of 2007–2020, they investigate the impact of size on the relationship between three ESG pillars and firms' stock market performance to conclude that larger firms engage in ESG activities

to benefit from the economies of scale and meet the demands and expectations of their major stakeholder groups.

In turn, under the overinvestment hypothesis, engagement in ESG activities diverts scarce resources from the maximisation of shareholders' wealth which, over time, may harm a firm's market value. In fact, the ESG-related expenditures may directly become an agency cost if managers use them to achieve their own benefits at the expense of shareholders [79]. Moreover, if some ESG activities serve merely for the purposes of "greenwashing", they may not only directly damage firms' market values, but more importantly have a prolonged negative impact on their reputation and financial performance, thus paradoxically leading to an increase in their ESG risk exposures.

The fact that large organizations are more exposed to various diseconomies of scale and efficiency challenges than smaller entities is well documented on both theoretical and empirical grounds [38]. Therefore, as the firm size increases, the identification, management, and mitigation of relevant ESG risks may become more challenging. In particular, large firms are typically more prone to employ bureaucratic control mechanisms involving written regulations, codes of conduct, or cultural norms in their efforts to control ESG risks [24]. While bureaucratisation may offer effective solutions to standard and recurring problems, when combined with the typical inertia that is inherent to large organizations, it can considerably impede their ability to cope with complex and often dynamically changing challenges of sustainability.

The direct empirical evidence on the impact of size on ESG performance in non-financial enterprises is relatively modest and mixed. According to Udayasankar [80], the relationship between firm size and CSR participation is likely to be U-shaped due to diverse motivational bases reflecting the disparities in visibility, access to resources, and the scale of operations among firms of different sizes. Under this view, both small and large enterprises tend to be the most motivated to engage in CSR-related activities, whereas medium-sized ones may face fewer incentives and be less pressured to follow a similar pattern.

The results of a study by Aouadi and Marsat [81], examining a sample of 4000 companies from 58 countries over the period of 2002–2011, indicate that firms' size is positively correlated with both their CSP scores and number of reported ESG controversies. These findings seem to corroborate the view that even if larger firms may often perform better in terms of CSR, the scale of their operations also renders them more exposed to various ESG risks. Moreover, Aouadi and Marsat [81] demonstrate that a positive impact of corporate social performance on market values appears to be limited to larger and high-attention firms.

The results of a study by Drempetic et al. [7], using the cross-sectional data from the Thomson Reuters ASSET4 ESG database for more than 3800 companies over the period of 2004–2015, suggest that, since ESG ratings are essentially dependent on both the availability of relevant data and the resources needed to process and provide them, ESG scores are driven by organisational legitimacy and tend to be biased in favour of larger companies. According to Drempetic et al. [7], however, better ratings need not imply a more efficient management of ESG risks, as larger firms may simply devote more resources to acquire, process, and report ESG-related information, regardless of their actual performance in that area. Such an effect would in turn mean that, instead of actual sustainability performance, ESG ratings are more likely capturing related data processing and reporting capabilities [74].

The findings of Drempetic et al. [7] are corroborated in a recent study by Dobrick et al. [37], who examine a sample covering more than 12,000 companies with LSE Refinitiv ESG scores over the period of 2003–2021, and report the presence of a strong size-bias, not only on the aggregate level, but also in terms of each of the three investigated sustainability pillars.

Akgun et al. [47] examine the sample of all companies included in the Russel 3000 Index over the period from 31 January 2015 to 30 October 2020, finding a positive, yet practically negligible correlation between firm size (as measured based on market capitalisation) and ESG scores based on MSCI data. They report a cross-sectional pairwise correlation between the examined variables of only 0.15 for large-capitalisation companies (included

in the Russel 1000 Index), and almost zero (0.08) for the remainder of the examined firms (members of the Russel 2000 Index). These results suggest that the "large cap bias" in corporate social performance reported in earlier studies might be fading in recent years.

A study by Gregory [74] demonstrates that, even though, in the cross-section of industries, ESG ratings seem to be generally positively related to firm size (as measured based on market capitalisation), after controlling for the sector, rating agency, and the presence of outliers, the effect disappears or even becomes negative. As regards the financial industry, the reported results are also mixed: for four out of five examined datasets on ESG ratings from different agencies, the results of OLS indicate a positive relationship with market capitalisation; however, for two of them, the associations become insignificant when quantile regression is applied, thus suggesting an evident sensitivity of outcomes to outliers in the sample. Finally, in the case of one rating agency, the relationship between ESG performance and firm size remains insignificant regardless of the estimation method.

2.2. The Impact of Size on Financial Performance, Risk, and ESG Performance in the Banking Industry

The empirical findings on the role of size in the banking industry seem equally diversified as in the case of non-financial sectors. In turn, direct evidence on its relationship with ESG performance and risk is even more scarce.

Similarly to other industries, banking also offers potential benefits related to economies of scale and scope. Larger banks usually profit from more diversified business models [82] and easier access to human and capital resources. In particular, they may offer artificially higher wages to attract highly skilled specialists [83] and take advantage of a wider range of sources of funds, often available at lower costs than in the case of smaller banks [84]. Additionally, the more diversified sources of revenue in larger banks usually result in a markedly higher share of noninterest income than in smaller counterparts. In turn, the differences in the perception of the persistence of individual noninterest income components may affect bank valuation and risk assessment by equity investors [85].

The existing evidence suggests the presence of increasing returns to scale in banking activity [86,87], which partially justifies the growth in the average size of banks and in the concentration of the industry. Some studies, however, argue that such benefits may be attributable primarily to the reduced funding costs resulting from investor expectations of government support in the case of financial distress under the "too big to fail" (TBTF) framework [88].

According to Minton et al. [42], the TBTF status grants the largest banks a unique "asset" in the form of a claim on public resources, which, in turn, may become an important source of their competitive advantage over smaller counterparts [89]. In fact, the benefits associated with the TBTF status may sometimes motivate banks to increase the size and riskiness of their operations beyond the levels justified by economies of scale and scope [84]. On the other hand, however, larger banks are also often exposed to higher costs resulting from greater regulatory requirements and scrutiny or political risk. A larger scale of operations may also impede the ability of shareholders to efficiently monitor bank management actions, which in turn increases the overall agency costs [42].

Although the positive impact of size on profitability in the banking industry seems to be relatively well documented in the relevant literature (see, e.g., [90–93]), some studies report an insignificant relationship [94] or suggest that the positive effect fades if banks become too large [95].

The findings of studies exploring the relationship between bank size and market value are also ambiguous. While some authors report a positive association [96,97], others argue that increases in size may be detrimental to bank stock prices [42,43,98,99] or that the investigated relationship is statistically insignificant [100]. Furthermore, Avramidis et al. [101] argue that the relationship between the market-to-book values of assets and the size of banks is inversely U-shaped due to the fact that, beyond a certain level, the benefits

achieved from economies of scale start to be offset by increases in costs related to monitoring borrowers and transactions, as well as the costs of the supervision of bank management by shareholders.

As banks become larger, managing them naturally becomes more challenging due to problems with efficient supervision and coordination of actions, internal communication, or ensuring the proper employee motivation. Not surprisingly, therefore, larger banks are often more exposed to diseconomies of scale [97] than their smaller peers. Additionally, with an increase in the size of their operations, larger banks are more exposed to various risks, in particular those of a systemic and non-diversifiable nature [102]. Greater size also tends to coincide with higher levels of tail risk, including its non-systematic component [103]. Lastly, larger banks are typically more exposed to sovereign risk, as they tend to keep relatively bigger holdings of government bonds than smaller institutions [104,105].

Even though it would seem that larger banks should benefit from more diversified capital allocation opportunities, empirical evidence suggests that an increase in size may lead to growth in both the leverage ratios and the share of risky assets in banks' portfolios [39], as well as their overall appetite for risk (as measured based on the risk ratings of originated loans) [41]. Other studies, however, do not find statistically significant differences in risk taking between larger and smaller banks [40]. Additionally, Minton et al. [42] demonstrate that the relationship between the scale of bank activities and risk may be non-linear, since the probability of distress increases with size for smaller banks, but tends to decrease again for larger ones. When leverage is used as a proxy of risk, though, it tends to increase with size for larger banks, but for smaller ones, the relationship turns out to be insignificant. In turn, Di Tomasso and Thornton [43] report that, on the one hand, size is negatively related to bank z-scores (suggesting that bigger banks are more risky), but on the other, it also exhibits a significant negative relationship with CDS spreads and ratios of non-performing loans (which would imply that larger size contributes to a reduction in bank risk). The above findings suggest a largely complex and multifaceted nature of the relationship between size and risk in the banking sector. It seems that size affects various areas of bank risk in different ways, and that the direction of the relationship may be conditional on the relevant contextual and bank-specific factors.

Given the ambiguous results of studies exploring the impact of size on various dimensions of banking activity, it comes as no surprise that an analogous vagueness is present in the evidence exploring its interaction with ESG performance and risk. In general, the very existence and viability of banks are almost entirely dependent on reputation and public trust. Banks are therefore both highly exposed and sensitive to ESG-related concerns, which directly affects the riskiness [12] and profitability [11] of their activities. Given the above, banks, even more than other industries, should be motivated to follow the principles of CSR and efficiently manage ESG risk [10]. Also, the empirical evidence on the impact of banks' engagement in ESG activities on their financial performance is generally mixed. While some studies suggest that an incorporation of ESG-related criteria in decision-making processes has a negligible impact [28,32,78] or even impedes banks' financial performance [106,107], others argue exactly the opposite [108,109].

As regards the relationship between ESG performance and risk, a study by Di Tomasso and Thornton [43] demonstrates that high ESG scores tend to be associated with a modest reduction in bank risk taking, which seems to be consistent with the "stakeholder" view of ESG activities. On the other hand, however, better ESG performance appears to coincide with relatively lower market values, thus supporting the "overinvestment" hypothesis, under which ESG-related activities divert scare resources from more value-enhancing uses. Moreover, several investigations report that individual dimensions of ESG frameworks may exert different impact on banks' performance [36,110].

As regards the evidence investigating the impact of banks' size, prior studies usually employ it merely as a control variable in analyses of the mutual interactions between ESG orientation, financial performance, and risk in the financial sector. Somewhat surprisingly, therefore, the direct empirical evidence on the impact of size on banks' ESG performance

and risk is nearly absent. For instance, Chih et al. [28] investigate over 500 financial entities from 34 countries over the period of 2003–2005 in search of the linkages between CSR and financial performance, and report a positive link between firm size and CSR orientation. Shen et al. [32] use a sample covering the data for 18 countries over the period of 2000–2009, and find that more socially responsible banks usually have a larger size, as measured based on their total assets, loans, and deposits. According to Shen et al. [32], engagement in socially responsible activities not only increases the realised ROA, ROE, and net interest income ratios, but also contributes to an improvement in credit risk management, as indicated by lower ratios of non-performing loans. Interestingly, however, the positive effect of CSR on financial performance appears to fade as bank size increases. In turn, Neitzert and Petras [111] provide evidence on the capability of ESG orientation to reduce bank risk. Having examined a sample of 582 banks worldwide over the period of 2002–2008, they conclude that the above effect is attributable primarily to environmental activities. In contrast to Shen et al. [32], however, they report that bank size does not significantly affect the examined relationship.

The results of a research study by Chiaramonte et al. [34], investigating a sample of European banks from 21 countries over the period of 2005–2017, suggest that banks with higher ESG scores tend to be less prone to insolvency in times of financial distress, which implies that following ESG principles may reduce bank fragility. A more detailed investigation, however, leads them to the conclusion that the above effect is statistically significant only in the subsample of the largest banks (being subject to EBA stress testing) and in countries with bank-oriented financial systems. Additionally, the effect appears to be stronger in richer countries (with a per capita GDP above the mean).

Menicucci and Paolucci [110] investigate the relationship between ESG and financial performance using a sample of 105 Italian banks in 2016–2020 and report different results for individual sustainability dimensions. As regards the impact of bank size, they find that it also tends to vary in terms of both direction and statistical significance depending on the choice of performance measure.

According to the Roland Berger GmbH report authored by Van Gysegem and Blaser [35], investigating a sample of more than a hundred European banks over the period of 2002–2020, banks' size reveals a strong positive correlation with their ESG scores. Unfortunately, besides that claim, the report does not disclose any quantitative details supporting that conclusion. The authors of the report argue that the above result can be justified not only on the grounds of the slack resources hypothesis (as larger banks are able to allocate more funds to internal social initiatives and improved governance structures or dedicated sustainability teams), but it also may reflect the fact that larger banking groups are likely more aware of their structural societal impact.

Having examined the data for 473 banks from 75 countries over the period of 2007–2016, Albdiwy et al. [44] report that bank size moderates the impact of ESG engagement on bank financial stability. Their findings indicate that ESG positively affects financial stability in larger banks, whereas in the case of smaller entities, the impact appears to be negative. In turn, a study by Quang Trinh et al. [45] demonstrates that even though larger banks generally tend to have a higher tail risk than their smaller counterparts, they also exhibit a significantly stronger mitigating impact of environmental and social performance on that risk.

Evidence by Andries and Sprincean [18] based on an investigation of 493 banks from 39 advanced and emerging economies over the period of 2003–2020 suggests that, although the incorporation of ESG practices into banks' business decisions enables them, on average, to reduce their funding costs, the effect is more pronounced for larger banks.

Finally, in a recent study on the relationship between ESG-related activities and financial performance, Gutiérrez-Ponce and Wibowo [36] examine a sample of five Indonesian banks over the period of 2010–2020 and report a relatively strong and statistically significant positive correlation between their Thomson Reuters Refinitiv ESG scores and bank size, as proxied by the logarithm of total assets. However, when the individual sustainability

pillars are concerned, the relationship with size seems to hold only for environmental and social components, whereas for the governance dimension, it turns out to be insignificant.

This review of the relevant literature suggests that the direct empirical evidence on the relationship between size and ESG performance in the banking sector is very scarce and largely mixed. Most of the relevant studies employ size merely as a control variable when examining the impact of ESG performance on bank financial performance or risk. In addition, it seems that, to date, no study has attempted to thoroughly explore the relationship between bank size and ESG risk from both theoretical and empirical perspectives. Given the above, the present study aims at filling this gap in the relevant literature.

3. Research Design

3.1. Hypothesis Development

The review of the relevant literature presented in the previous section suggests that banks' size exerts a two-way impact on their ESG risk (Figure 1).

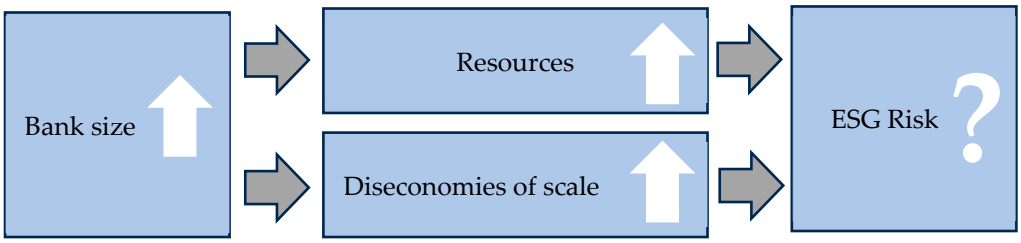

Figure 1. The relationship between bank size and ESG risk.

On the one hand, as the size of a company grows, more human, capital, and knowledge-based resources may be allocated to the identification and mitigation of ESG risk [24,30,31,34], allowing firms to benefit from economies of scale [74]. Additionally, the higher availability and often quality of the allocated resources, combined with greater stakeholder pressure in larger firms [25,78], contribute to the larger supply and informativeness of their ESG-related disclosures [24,26,27,29,33] that lead to a positive association between company size and ESG performance scores [7,37]. Substantial economies of scale and scope in the banking industry [86,87] and a positive association between size and ESG performance scores reported in prior studies [28,32,35,36] allow us to expect similar effects to the ones reported for non-financial enterprises. The above considerations lead to the formulation of the baseline hypothesis of the present study:

H1. *Firm size is negatively associated with ESG risk in the cross-section of the international banking industry.*

On the other hand, however, following the evidence provided in the relevant literature [24,38,42,81,97], larger size causes, ceteris paribus, a build-up of various "diseconomies of scale", resulting from inefficiencies caused by bureaucratic inertia, more numerous and complex business interactions, a larger overall environmental and social impact, agency problems, and other corporate governance-related issues. Following the overinvestment hypothesis, an excessive and unfounded allocation of resources to ESG risk management [79] may, paradoxically, lead to an additional build-up of the diseconomies of scale and the amplification of their adverse impact. In particular, as demonstrated by Aouadi and Marsat [81], even though larger size generally involves better ESG performance, at the same time, it also leads to a greater number of related controversies. Furthermore, in the specific context of the banking industry, the benefits expected from obtaining TBTF status may incline banks to increase their sizes beyond the levels justified by economies of scale and scope [84]. This notion is further corroborated by the empirical evidence in other studies reporting a positive association between size and various dimensions of bank risk [38,41,45,102–105].In fact, the trade-off between available resources and disec-

onomies of scale may also be partially responsible for the low statistical significance of the impact of company size on both ESG performance [47,74] and its relationship with financial performance [95] or bank risk [111] reported in prior studies.

The diseconomies of scale and various risks building up as a consequence of increases in size partially offset the mitigating impact of resource allocation capability, which renders the ultimate impact of size on banks' ESG risk ambiguous and likely varying with the size itself. The non-linearities reported in the prior studies investigating the relationships between company size and ESG performance [80,95,101], risk [42], or their mutual linkages [32,44] allow us to expect that the relationship between bank size and ESG risk may also be non-linear. Under the assumptions that (1) both resources allocated to the mitigation of ESG risk and diseconomies of scale (DoS) increase with size, (2) ESG risk is inversely related to the amount of resources allocated to its mitigation, and (3) rising diseconomies of scale cause a more than proportionate increase in ESG risk, the relationship between bank size and ESG risk becomes U-shaped (Figure 2).

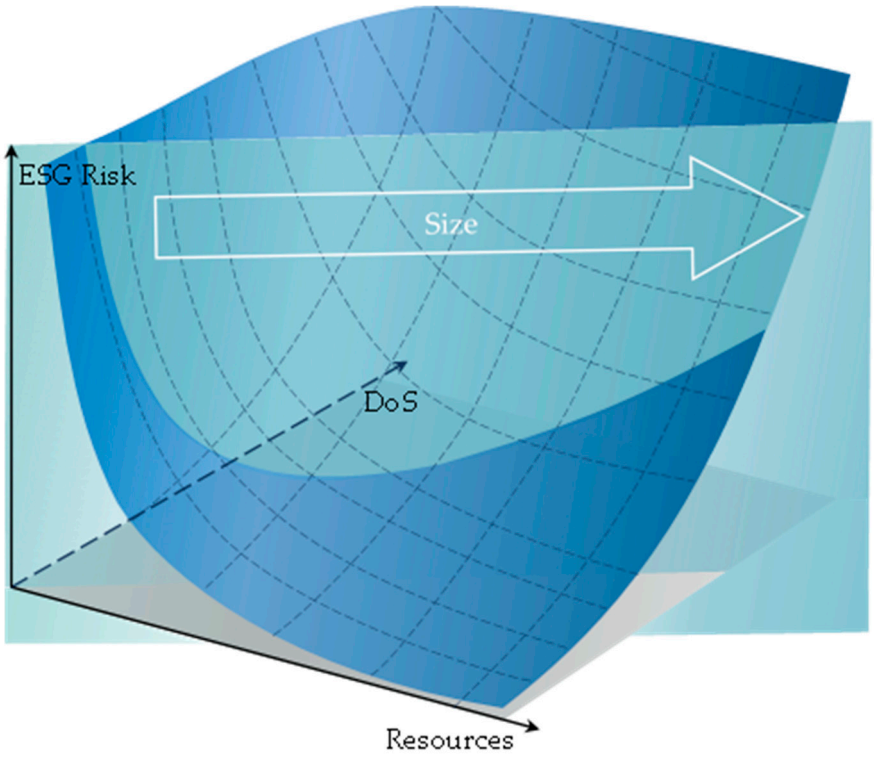

Figure 2. Non-linearities in the relationship between bank size and ESG risk.

Initially, as the size of banking activity increases, the benefits arising from the allocation of additional human, capital, and knowledge-based resources to the mitigation and reporting of ESG risk prevail over the offsetting impact of diseconomies of scale, thus leading to a decrease in the overall level of ESG risk. Beyond a certain threshold, however, the relationship reverses, as the mounting diseconomies of scale start to outweigh the beneficial effects of resource allocation and drive the ESG risk up again. Hence, the above deliberations allow us to formulate the second hypothesis of the present study:

H2. *The relationship between firm size and ESG risk in the cross-section of the international banking industry is U-shaped.*

Therefore, in the light of both formulated hypotheses, although ESG risk is expected to generally decrease with size in the cross-section of banks, as suggested by the majority of prior studies, the relationship is likely non-linear and characterised by convexity due to the adverse impact of various inefficiencies and diseconomies of scale. In fact, it is also

plausible that, when a bank exceeds a certain size, the above impact may cause their ESG risk to increase, thus forming a U-shaped relationship between the examined variables.

3.2. Data and Methods

The assessment of banks' ESG risk exposures is based on the ESG Risk Ratings by Morningstar Sustainalytics [112]. The ratings are designed to measure the magnitude of companies' unmanaged ESG risks, which represents the degree to which their economic value is at risk, driven by ESG factors. The ratings are measured on an open-ended scale starting at 0 (i.e., no unmanaged risk) and, for 95% of cases, a maximum score below 50 [113]. Depending on their individual quantitative score, companies are assigned to one of five risk categories: negligible [0–10), low [10–20), medium [20–30), high [30–40), and severe (equal to or above 40).

Following the theoretical considerations presented in the literature review (Section 2) and in the development of the hypotheses (Section 3.1), as well as taking into account the fact that the focus of the present study is set on investigating the relationship between size and ESG risk in the banking industry, the measures used to proxy for company size should reflect both the availability of resources required to manage ESG risk and the specificity of banking activities. Therefore, the assessment of bank size for the purposes of the present study is based on the two most fundamental resource-related dimensions of bank size, i.e., the book value of their total assets (TA), which is by far the most frequently employed measure of firm size with respect to capital resources in empirical corporate finance [114], and the total number of employees (E) which proxies for human resources (other measures of company size often used in the relevant literature include market capitalisation and total revenue; however, as highlighted by Dang et al. [114], the former is focused primarily on firm growth opportunities and equity market conditions, whereas the latter largely reflects product market competition. Moreover, in the case of the banking industry, the incremental informativeness of total revenue seems limited, as the vast majority of revenue comes from interest and fee incomes, and thus, it is strongly dependent on the volumes of total assets).

Moreover, as pointed out by Dang et al. [114], different measures of firm size exhibit their own advantages and disadvantages, and no single measure can capture all characteristics of "firm size"; therefore, given the above deliberations, the present study attempts to gauge the size of the investigated banking companies using a composite indicator encompassing two aforementioned dimensions within a single measure.

First, the data for each dimension are normalised using the min–max procedure:

$$TA_{it}^{n} = \frac{TA_{it} - \min(TA_{it})}{\max(TA_{it}) - \min(TA_{it})} \tag{1}$$

$$E_{it}^{n} = \frac{E_{it} - \min(E_{it})}{\max(E_{it}) - \min(E_{it})} \tag{2}$$

Next, the composite size index (*CSI*) is calculated as the arithmetic mean of the normalised scores:

$$CSI_{it} = \frac{TA_{it}^{n} + E_{it}^{n}}{2} \tag{3}$$

In order to investigate the general relationship between size and ESG risk in the examined sample, and to test the first hypothesis of the present study (H1), the following baseline linear regression model is employed (Model 1):

$$ESG\_Risk_{it} = \alpha_0 + \alpha_1 CSI_{it} + \varepsilon_{it} \tag{4}$$

where

- ESG_Risk_{it}—the value of ESG risk rating for a company (i) in year t;
- CSI_{it}—the value of the composite size index for a company (i) in year t;
- α_0, α_1—structural parameters;

- ε_{it}—error term.

As ESG risk is hypothesized to decrease with size in the cross-section of banks, the estimated value of the coefficient α_1 is expected to be negative.

In the next step, to test the second hypothesis of this study (H2) regarding the presence of non-linearities in the form of a U-shaped relationship between the investigated variables, the model is extended by introducing the squared value of the *CSI* (Model 2):

$$ESG\_Risk_{it} = \beta_0 + \beta_1 CSI_{it} + \beta_2 CSI_{it}^2 + \epsilon_{it} \quad (5)$$

where

- β_0, β_1, β_2—structural parameters;
- ϵ_{it}—error term.

Following the second hypothesis of the present study (H2), the coefficient β_2 is expected to be positive, while the first one (H1) allows us to anticipate a negative estimate of the coefficient β_1. As pointed out by Lind and Mehlum [115], however, in some circumstances, the statistical significance of the estimated regression parameters alone may not be enough to demonstrate the existence of a U-shaped relationship. Given the above, they recommend using an additional testing procedure designed specifically to verify whether the investigated relationship decreases at low values and increases at high values within a given data interval. Therefore, to improve the overall strength of the formulated statistical inferences on the shape of the relationship between size and ESG risk in the cross-section of the international banking industry, the present study also employs the Lind–Mehlum appropriate test for U-shaped relationships [115].

The final stage of this research involves testing the robustness of the results. First, to check whether the findings also hold for individual size dimensions, the variable *CSI* in Models 1 and 2 is substituted with TA and TE, yielding the following regressions:

1. Model 1A:

$$ESG\_Risk_{it} = \alpha_0^A + \alpha_1^A TA_{it} + \varepsilon_{it}^A \quad (6)$$

2. Model 1E:

$$ESG\_Risk_{it} = \alpha_0^E + \alpha_1^E E_{it} + \varepsilon_{it}^E \quad (7)$$

3. Model 2A:

$$ESG\_Risk_{it} = \beta_0^A + \beta_1^A TA_{it} + \beta_2^A TA_{it}^2 + \epsilon_{it}^A \quad (8)$$

4. Model 2E:

$$ESG\_Risk_{it} = \beta_0^E + \beta_1^E E_{it} + \beta_2^E E_{it}^2 + \epsilon_{it}^E \quad (9)$$

Next, the regression models are extended to control for the presence of country-specific contextual factors that may affect bank ESG risk [116]. For simplicity, it is assumed that, for each company in the examined sample, the above effect is limited only to its headquarter country. The impact of contextual factors is proxied by means of a composite index constructed on the basis of the following country-level measures related to ESG risk:

1. SolAbility's Global Sustainable Competitiveness Index [117]:
2. The United Nations' Human Development Index [118];
3. Transparency International's Corruption Perceptions Index [119].

The fact that, for each of the above indices, higher values reflect more favourable conditions for ESG risk management has enabled us to merge them into a single measure, capturing the contextual risk factors at the country level. Therefore, after normalising the data using the min–max procedure, the composite contextual factors index (*CCFI*) is calculated for each bank's headquarter country as the unweighted average of the normalised scores. Next, the index is introduced in the models given in Equations (4) and (5), yielding their following extended versions (Model 3 and Model 4, respectively):

$$ESG\_Risk_{it} = \gamma_0 + \gamma_1 CSI_{it} + \gamma_2 CCFI_{jt} + \vartheta_{it} \quad (10)$$

$$ESG\_Risk_{it} = \delta_0 + \delta_1 CSI_{it} + \delta_2 CSI_{it}^2 + \delta_3 CCFI_{it} + \xi_{it} \quad (11)$$

where

- $CCFI_{it}$—the value of the composite contextual factors index for a bank's (i) headquarter country in year t;
- γ_0, γ_1, γ_2 and δ_0, δ_1, δ_2, δ_3—structural parameters;
- ϑ_{it} and ξ_{it}—error terms.

Analogously, as in the preceding specifications of the models, under H1, the estimated values of the parameters γ_1 and δ_1 are expected to be negative, while H2 allows us to anticipate a positive estimate of the parameter δ_2. Finally, since higher values of $CCFI_{it}$ should generally indicate more favourable conditions for ESG risk management, the estimated value of the parameter δ_3 is expected to be negative.

Initially, each of the constructed linear and non-linear models is estimated using ordinary least squares (OLS) with robust standard errors to control for the heteroskedasticity of error terms. Following the evidence provided by R. P. Gregory [74], however, the robustness of the results is further tested by re-estimating the models using quantile regression to investigate the impact of outliers on the obtained outcomes. All the estimations in this study was obtained using the Stata/SE 14.0 software.

The initial sample of firms for the purposes of the present study was extracted from the Morningstar Sustainalytics database and covered all (696) publicly traded companies classified as "banks" which were assigned an ESG Risk Rating for the year 2021. The choice of this time frame was a compromise between the aspiration to use the most recent data available on the one hand, and the need to avoid potential distortions resultant from the recent global adverse shocks caused by the COVID-19 pandemic or the full-scale war in Ukraine on the other.

In the next step, the sample was revised in order to identify firms that prepare their financial statements in the form typical for non-financial enterprises, and in which the actual extent of their banking activities is negligible. In effect, 28 companies were dropped, yielding a final sample of 668 banking companies. The composition of the sample based on headquarter countries is given in Table 1.

Table 1. Composition of the examined sample by country of headquarters.

Country	Number of Companies	Country	Number of Companies
Argentina	1	Nigeria	5
Australia	9	Norway	9
Austria	4	Oman	3
Bahrain	2	Pakistan	7
Belgium	2	Panama	1
Brazil	8	Peru	5
Canada	12	Philippines	7
Chile	3	Poland	10
China	40	Portugal	1
Colombia	7	Qatar	7
Czechia	2	Romania	1
Denmark	5	Saudi Arabia	10
Egypt	4	Singapore	2
Finland	2	Slovakia	2
France	4	Slovenia	1
Georgia	1	South Africa	6
Germany	5	South Korea	9
Greece	4	Spain	5
Iceland	2	Sweden	6
India	31	Switzerland	6
Indonesia	18	Taiwan	17

Table 1. *Cont.*

Country	Number of Companies	Country	Number of Companies
Ireland	2	Thailand	11
Israel	6	The Netherlands	2
Italy	12	Türkiye	11
Japan	59	UAE	12
Kuwait	9	UK	12
Malaysia	11	US	229
Mexico	4	Vietnam	1
New Zealand	1		

Data on the value of total assets and the total number of employees for the end of the fourth quarter of 2021 were extracted from the online databases of the "Financial Times" [120], "The Wall Street Journal" [121], and MarketWatch [122]. The remaining data gaps were filled on the basis of the respective companies' annual and sustainability reports.

Table 2 presents the key descriptive statistics of the investigated variables.

Table 2. Summary statistics.

Variable	N	Mean	Median	Min	Max	SD	Kurtosis	Skewness
ESG_risk_{it}	668	28.0534	28.50000	7.90000	51.10000	6.53135	3.62870	−0.12971
CSI_{it}	668	0.03601	0.00701	0.00018	0.96685	0.09568	42.53835	5.66221
$CCFI_{it}$	668	0.64412	0.73300	0.02800	0.97600	0.20374	3.33236	−1.01438

The data in Table 2 show that the distribution of the *CSI* is strongly leptokurtic and right-skewed, which indicates that the examined sample is characterised by both a significant predominance of relatively smaller-sized banking institutions and the presence of extremely large outliers. In the case of the remaining variables, the departures from normal distribution seem much less pronounced; however, both are slightly leptokurtic and left-skewed.

4. Results

4.1. Regression Analysis

The results of the estimation of Model 1 are reported in Table 3.

Table 3. Estimation of Model 1.

Model 1: $ESG\_Risk_{it} = \alpha_0 + \alpha_1 CSI_{it} + \varepsilon_{it}$						
Parameter/ Statistic	**Estimate/ Value**	**Robust Standard Error**	**t**	***p*-Value**	**95% Confidence Interval**	
α_0	28.27394	0.26519	106.619	0.0000	27.75324	28.79465
α_1	−6.12313	2.84622	−2.151	0.0318	−11.71179	−0.53448
F	4.63			0.0318		
R^2	0.0080					
Adj. R^2	0.0065					
N	668					

In line with expectations, the estimate of the coefficient α_1 is negative, suggesting that a larger size is generally associated with lower ESG risk in the cross-section of the examined banking companies. The above finding therefore provides some initial support for the first hypothesis of the present study (H1). Although the regression is significant at the 0.05 level, the near-zero value of the coefficient of determination and significantly positive intercept clearly indicate that the variation in size alone is not able to explain the cross-sectional variability of banks' ESG risk.

The next step of this research involved the estimation of Model 2 to test the hypothesised U-shaped relationship between size and ESG risk in the banking industry (Table 4).

Table 4. Estimation of Model 2.

Model 2: $ESG\_Risk_{it} = \beta_0 + \beta_1 CSI_{it} + \beta_2 CSI_{it}^2 + \epsilon_{it}$						
Parameter/ Statistic	**Estimate/ Value**	**Robust Standard Error**	**t**	***p*-Value**	**95% Confidence Interval**	
β_0	28.75424	0.26909	106.856	0.0000	28.22587	29.28262
β_1	−31.40918	5.86380	−5.356	0.0000	−42.92297	−19.89538
β_2	41.22467	8.08443	5.099	0.0000	25.35059	57.09874
F	14.37			0.0000		
R^2	0.0396					
Adj. R^2	0.0367					
N	668					

The entire model and each of the regression coefficients are statistically significant at all conventional levels. A negative value of the estimate of the coefficient β_1, along with a positive one for β_2, suggest a U-shaped relationship between size and ESG risk in the cross-section of the examined banks, thus supporting the second hypothesis of this study (H2). In addition, the results of the estimation allow us to determine the *CSI* threshold beyond which the relationship between bank size and ESG risk starts to reverse; using the formula for the abscissa of the vertex of a parabola, the value of this threshold is 0.381.

The above findings are further corroborated by the results of the Lind–Mehlum test for a U-shaped relationship (Table 5).

Table 5. The Lind–Mehlum test for a U-shaped relationship for Model 2.

Parameter/ Statistic	**Lower Bound**	**Upper Bound**
Interval	0.00018	0.96685
Slope	−31.39401	48.30679
t-value	−5.238	4.052
p-value	0.0000	0.0000
95% Fieller interval for extreme point	0.31896	0.47472
Extreme point	0.38095	
Overall test for presence of a U-shape:		
t-value	4.052	
p-value	0.0000	

As indicated by the data in Table 5, the results of the Lind–Mehlum test confirm the presence of a U-shaped relationship between size and ESG risk in the cross-section of the international banking industry at all conventional levels of significance, thus providing additional support for the second hypothesis of the present study.

Despite some improvement in the explanatory power of Model 2 in comparison to Model 1, the results of the estimation still suggest that the variation in bank size is able to explain only a very small fraction of the general variability of ESG risk in the banking industry, even if the non-linear nature of the relationship is taken into account.

4.2. Robustness Tests

The second stage of this research involved testing the robustness of the obtained results. First, Models 1A, 1E, 2A, and 2E were estimated to check whether the results of the baseline estimations hold when the individual size dimensions, i.e., the book value of total assets and the total number of employees, are used as regressors instead of the constructed composite size index (Table 6).

Table 6. Estimations of Models 1A, 1E, 2A, and 2E.

Model	Parameter/ Statistic	Estimate/ Value	Robust Standard Error	t	*p*-Value	95% Confidence Interval	
1A	α_0^A	28.30983	0.26542	106.66	0.0000	27.78867	28.83100
	α_1^A	−1.32564	0.47878	−2.769	0.0058	−2.26575	−0.38554
	F	7.67			0.0058		
	R^2	0.0138					
	Adj. R^2	0.0123					
1E	α_0^E	28.18218	0.26047	108.199	0.0000	27.67075	28.69361
	α_1^E	−0.00761	0.00545	−1.398	0.1627	−0.01831	0.00308
	F	1.95			0.1627		
	R^2	0.0026					
	Adj. R^2	0.0011					
2A	β_0^A	28.77206	0.27123	106.082	0.0000	28.23949	29.30462
	β_1^A	−6.57645	1.07082	−6.142	0.0000	−8.67904	−4.47387
	β_2^A	1.48990	0.27194	5.479	0.0000	0.95594	2.02387
	F	19.21		0.0000			
	R^2	0.0517					
	Adj. R^2	0.0488					
2E	β_0^E	28.55870	0.27208	104.963	0.0000	28.02446	29.09294
	β_1^E	−0.04880	0.01484	−3.288	0.0011	−0.07794	−0.01966
	β_2^E	0.00015	0.00004	3.273	0.0011	0.00006	0.00023
	F	5.54		0.0041			
	R^2	0.0209					
	Adj. R^2	0.0179					
	N	668					

As demonstrated by the data in Table 6, the general properties of Models 1 and 2 seem to hold when individual size dimensions (i.e., TA or E) are also employed in estimations instead of the composite index (*CSI*). All estimated regression coefficients, except for α_1^E in Model 1E, have turned out to be statistically significant at all conventional levels. The negative estimates of the coefficients α_1^A and α_1^E suggest that size remains negatively related to ESG risk in the cross-section of the examined banks when the book value of total assets or the total number of employees are also used as single explanatory variables, although in the latter case, the association appears to be insignificant. In turn, the estimations of Models 2A and 2E (i.e., the negative estimates of parameters β_1^A and β_1^E along with the positive ones for β_2^A and β_2^E, respectively) demonstrate clearly that the U-shaped pattern in the investigated relationship holds and is statistically significant for each of the individual variables proxying for bank size.

Similarly, as in the case of the original Model 2, the Lind–Mehlum test for a U-shaped relationship was applied to Models 2A and 2E (Table 7).

As indicated by the data in Table 7, the results of the Lind–Mehlum test confirm the presence of a U-shaped relationship with bank ESG risk for each of the examined single explanatory variables (i.e., the book value of total assets and the total number of employees) at all conventional levels of significance.

In the second stage of the robustness tests, each of the baseline models were enhanced by the introduction of additional explanatory variables designed to capture the impact of country-specific contextual factors (*CCFI*) that may likely affect both banks' overall exposure to ESG risk and their ability to manage it.

The results of the estimation of Model 3, being an enhanced version of Model 1, are given in Table 8.

Table 7. The Lind–Mehlum test for a U-shaped relationship for Models 2A and 2E.

Parameter/ Statistic	Model 2A		Model 2E	
	Lower Bound	**Upper Bound**	**Lower Bound**	**Upper Bound**
Interval	0.01	5518.14	83	455,174
Slope	−0.00658	0.00987	−0.00005	0.00008
t-value	−5.954	4.458	−3.746	3.158
p-value	0.0000	0.0000	0.0001	0.0008
95% Fieller interval for extreme point	1919.64	2645.46	127,166	228,959
Extreme point	2207.01		166,378	
Overall test for presence of a U-shape:				
t-value	4.458		3.158	
p-value	0.0000		0.0008	

Table 8. Estimation of Model 3.

Model 3: $ESG\_Risk_{it} = \gamma_0 + \gamma_1 CSI_{it} + \gamma_2 CCFI_{it} + \vartheta_{it}$						
Parameter/ Statistic	**Estimate/ Value**	**Robust Standard Error**	**t**	***p*-Value**	**95% Confidence Interval**	
γ_0	32.99575	0.95722	34.470	0.0000	31.11622	34.87529
γ_1	−5.20987	2.89335	−1.801	0.0722	−10.89106	0.47132
γ_2	−7.38166	1.38027	−5.348	0.0000	−10.09188	−4.67144
F	16.71			0.0000		
R^2	0.0609					
Adj. R^2	0.0581					
N	668					

The data in Table 8 indicate that the estimated regression is significant at all conventional levels. After introducing an additional explanatory variable ($CCFI_{it}$), the negative relationship between size and ESG risk still holds; however, the significance of the corresponding regression coefficient (γ_1) decreases. In line with expectations, the estimate of the coefficient γ_2, reflecting the impact of country-specific contextual factors, has turned out to be negative and statistically significant, implying that better overall sustainability performance, higher-quality human capital, and a lower risk of corruption in a given bank's headquarter country contribute to a reduction in the company's ESG risk. Despite some marginal improvement, the explanatory power of the model remains very low, suggesting that a bank's overall ESG risk is driven primarily by factors other than size and broad contextual variables.

The results of the estimation of Model 4 (an enhanced version of Model 2) are presented in Table 9.

The regression and each of the coefficient estimates have turned out to be significant at all conventional levels. The signs of the individual coefficient estimates are consistent with expectations, implying that the U-shaped relationship between size and ESG risk still holds in the cross-section of the examined banking companies after controlling for the impact of country-specific contextual factors. Once again, despite the fact that the inclusion of the variable $CCFI_{it}$ slightly improves the overall explanatory power of the model, the variability of the regressors is able to explain only less than 10% of the total variability in banks' ESG risk.

The third stage of the robustness analysis involved an investigation of the impact of outliers on the estimation results, following the evidence provided by R. P. Gregory [74]. To address this issue, Models 1–4 were re-estimated using quantile regression at the median values (Table 10).

Table 9. Estimation of Model 4.

$ESG\_Risk_{it} = \delta_0 + \delta_1 CSI_{it} + \delta_2 CSI_{it}^2 + \delta_3 CCFI_{it} + \xi_{it}$						
Parameter/ Statistic	**Estimate/ Value**	**Robust Standard Error**	**t**	***p*-Value**	**95% Confidence Interval**	
δ_0	33.79035	0.96079	35.170	0.0000	31.90381	35.67690
δ_1	−32.78269	5.72044	−5.731	0.0000	−44.01503	−21.55036
δ_2	45.03797	8.23089	5.472	0.0000	28.87626	61.19969
δ_3	−7.80356	1.38186	−5.647	0.0000	−10.51690	−5.09023
F	23.20			0.0000		
R^2	0.0984					
Adj. R^2	0.09436					
N	668					

Table 10. Results of quantile regression for Models 1–4.

Model	**Parameter/ Statistic**	**Estimate/Value**	**Standard Error**	**t**	***p*-Value**	**95% Confidence Interval**	
1	α_0	28.73088	0.26910	106.77	0.000	28.20248	29.25927
	α_1	−12.92368	2.63402	−4.91	0.000	−18.09566	−7.75170
	Pseudo R^2	0.0062					
2	β_0	29.13927	0.27025	107.82	0.000	28.60862	29.66992
	β_1	−43.90972	5.70136	−7.70	0.000	−55.10455	−32.71489
	β_2	54.34324	8.38019	6.48	0.000	37.88842	70.79807
	Pseudo R^2	0.0387					
3	γ_0	31.83050	0.92967	34.24	0.000	30.00506	33.65593
	γ_1	−12.02803	2.93054	−4.10	0.000	−17.78224	−6.27381
	γ_2	−4.66321	1.37620	−3.39	0.001	−7.36542	−1.96099
	Pseudo R^2	0.0148					
4	δ_0	33.10194	0.79879	41.44	0.000	31.53348	34.67040
	δ_1	−48.73958	5.71286	−8.53	0.000	−59.95702	−37.52214
	δ_2	61.26484	8.41097	7.28	0.000	44.74955	77.78013
	δ_3	−5.78178	1.16455	−4.96	0.000	−8.06842	−3.49515
	Pseudo R^2	0.0549					
	N	668					

The results of the estimations given in Table 10 indicate that the general properties of each model also hold under the quantile (median) regression. Compared to the OLS estimations, the signs of all regression coefficients remain unchanged, and their estimates are statistically significant at all conventional levels. In particular, the significantly negative coefficients α_1 (Model 1) and γ_1 (Model 3) demonstrate that, in the case of the banking industry, the overall negative association between company size and ESG risk is not caused merely by the presence of outliers, but may instead reflect a broader cross-sectional regularity, which also remains valid after controlling for the impact of country-specific contextual factors. The above findings therefore provide additional support for the first hypothesis of the present study. In turn, the results for Models 2 and 4, namely the significantly negative estimates for β_1 and δ_1, together with significantly positive ones for β_2 and δ_2, corroborate the second hypothesis, which assumes that the relationship between size and ESG risk is non-linear and follows a U-shaped pattern.

5. Discussion

The results of the conducted analyses seem to support both research hypotheses formulated in the present study. First, the empirical evidence suggests that, on average, ESG risk tends to decrease with firm size in the cross-section of the international banking industry. On the one hand, this finding seems to corroborate the slack resources hypothesis [24],

under which a larger size enables firms to assign more human, capital, and knowledge-based resources to ESG risk management, and suggests the presence of non-negligible economies of scale in that field [74,78]. The above conclusion is therefore largely consistent with the results of prior studies exploring the relationship between company size and ESG performance in both non-financial and financial sectors [18,28,30–32,34–36]. On the other hand, the negative association between bank size and ESG risk may also be explained on the grounds of the stakeholder [25] and organisational legitimacy [26] theories. Being more visible and scrutinized by their stakeholders, larger companies are likely both more externally pressured and internally motivated to provide the public with more informative and higher-quality ESG-related disclosures [24,26,27,29,33]. This, in turn, improves their transparency for the purposes of ESG risk assessment by external rating agencies, which may ultimately lead to better scores, as demonstrated by Drempetic et al. [7] or Dobrick et al. [37].

The results of the conducted robustness tests indicate that the key findings of the present study generally also hold when individual size dimensions, i.e., the book value of total assets or the total number of employees, are used as regressors instead of the constructed composite size index (*CSI*). First, each individual variable proxying for size exhibits an overall negative relationship with ESG risk in the cross-section of the examined banking companies; however, only in the case of the former one it is statistically significant. And second, analogously to the *CSI*, both variables reveal a statistically significant U-shaped relationship with ESG risk.

A further robustness analysis has demonstrated that, contrary to the findings of R. P. Gregory [74], the negative association between size and ESG risk in the cross-section of the international banking industry cannot be attributed merely to the presence of outliers in the examined sample, as the relationship also remains statistically significant under quantile (median) regression. Moreover, the empirical evidence indicates that the relationship also holds after controlling for the impact of country-specific contextual factors that likely affect firms' ESG risk at the aggregate level.

The obtained results indicate, however, that the variation in firm size alone is not sufficient to explain a meaningful fraction of the cross-sectional variability in bank ESG risk. Moreover, the descriptive power of the related regression models does not improve considerably after including the index of country-specific contextual factors as an additional explanatory variable. The above evidence suggests that the level of ESG risk in banks is driven primarily by their idiosyncratic features other than the size itself.

The findings of this study also suggest that, in the case of the banking industry, the relationship between size and ESG risk is non-linear and follows a U-shaped pattern, as indicated by the signs and statistical significance of the respective parameters of the constructed non-linear regression models, as well as the results of the Lind–Mehlum [115] test. Therefore, even though under the linear regression framework, the investigated association appears to be generally negative; a more detailed analysis reveals the presence of a statistically significant convexity, which may be attributed to the existence of the various diseconomies of scale and efficiency challenges faced by larger banks, as previously documented in the relevant literature (see, e.g., [24,38]), likely capable of partially offsetting the benefits related to a greater availability of resources and more informative ESG risk reporting. Additionally, the apparent non-linear nature of the size–ESG risk relationship may also be a reflection of the complex and often equivocal linkages between size, risk exposure, and ESG performance in the banking sector explored in prior studies (see, e.g., [39–45]).

The findings of this study offer some important lessons and recommendations for bank executives and equity investors. On the one hand, the results suggest that, on average, larger banking companies perform better in terms of ESG risk management, which, at a first glance, may be perceived as yet another incentive for banks to increase the scale of their business activities. On the other hand, however, the empirical evidence indicates that the relationship between size and ESG risk in the banking industry is in fact non-linear

and demonstrates a statistically significant convexity, which likely reflects the presence of non-negligible diseconomies of scale. Hence, bank executives should be aware that, as the size of their company increases, the related benefits in the area of ESG risk management may be gradually offset by the accruing diseconomies of scale and the growing number and complexity of related ESG concerns. Neglecting this issue and failing to apply properly tailored countermeasures may ultimately lead to a reversal of the relationship between bank size and ESG risk when further growth begins to drive the overall level of ESG risk up.

The awareness of the U-shaped relationship between size and ESG risk in the cross-section of the international banking industry may also prove relevant for equity investors and asset managers who wish to construct their portfolios in accordance with the principles of sustainable investing. Bearing in mind the in-built systemic incentives for banks to increase their size, ESG-aware investors may therefore attempt to adjust their portfolios in advance to avoid the undesirable build-up of related risk.

The main limitations of this study arise from the fact that the empirical evidence is based on international cross-sectional data observed at a single point in time. Hence, future research might try to validate the findings and conclusions of the present paper using panel data over longer time horizons, controlling for the likely individual heterogeneity in the sample. Another area worth scientific exploration is whether the patterns in the size–ESG risk relationship identified on the basis of international data hold also at the individual country level. Furthermore, future studies might attempt to identify the contextual or bank-specific variables affecting the strength and shape of the above association at the country level. Finally, it would also be worthwhile to examine if the size–ESG risk relationship differs between subsamples of Islamic and conventional banks.

Given the fact that the present study was designed specifically to investigate the relationship between company size and ESG risk in the cross-section of the international banking industry, it is worthwhile to point out that its findings should be interpreted solely within that context. Therefore, the obtained results do not allow the formulation of any general conclusions about the direction or shape of the examined relationship in other industries.

6. Conclusions

The present study was aimed at an empirical investigation of the linkages between size and ESG risk in the cross-section of the international banking industry, with a particular focus on the identification of non-linearities in the examined relationship. To the best of the author's knowledge, this issue has not been yet thoroughly explored in the relevant literature, which renders the present paper largely original and pioneering in the field.

The results of the uni- and multivariate linear and non-linear regression analyses applied to a broad international sample of banking companies demonstrate that, although size is, on average, negatively associated with ESG risk in the cross-section, the relationship is in fact non-linear and follows a U-shaped pattern. The findings generally hold when individual size dimensions (i.e., the book value of total assets or the total number of employees) are used as regressors instead of the composite size index. The obtained results are also robust regarding the impact of both country-specific contextual factors and the outliers in the sample. On the one hand, the findings of this study are therefore consistent with the stakeholder and organisational legitimacy theories, as well as the slack resources hypothesis, under which bigger firms are likely to perform better in the area of ESG risk management due to the larger availability of the required resources and more informative sustainability reporting. On the other hand, however, the revealed convexity of the relationship indicates the presence of non-negligible diseconomies of scale and/or the rising number and complexity of the ESG-related concerns that tend to accrue with size.

The main contributions of the present paper are threefold. First, this study enhances the relevant literature by systematising the existing theoretical and empirical evidence on the impact of size on ESG risk, with a particular focus on the specific context of the banking sector. Second, this paper provides a thorough theoretical underpinning and empirical examination of the linkages between size and ESG risk in the cross-section of

the international banking industry, highlighting the non-linear nature of the relationship. Third, the findings of this study emphasize the importance of diseconomies of scale in the area of ESG risk management, thus offering some important practical lessons and recommendations for bank executives, as well as for ESG-oriented equity investors and asset managers.

Given the innate tendency of banks to expand the scale of their businesses on the one hand, and the constantly growing global awareness of the importance of ESG-related concerns on the other, the in-depth exploration of the impact of size on ESG risk in the banking industry seems vital, not only from the standpoint of the decision-making processes of bank executives, but also those of equity investors and asset managers who construct their investment portfolios by taking into account the magnitude of ESG risk exposure. This, in turn, gives rise to a continuation of the research efforts in the above area, as suggested in the discussion section (Section 5).

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Exploring Generation Z's Investment Patterns and Attitudes towards Greenness

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Abstract: Financial technology is quickly developing, making the financial industry more accessible and encouraging individual investor engagement in the investing process. Generation Z, characterised by a high level of digital literacy, curiosity, and receptivity to innovation, tends to very quickly make decisions and rapidly consume. Since 2007, there has been an increase in the number of articles analysing investor behaviour, drawing on insights from financial and psychological theories. The purpose of this exploratory study is to categorise the behaviour of students surveyed by the type of their investments, while at the same time assessing their willingness to choose green investments. The survey used in the analysis not only aims at collecting data but also educates students on the importance of critical self-awareness and the identification of their emotions to make rational, responsible investment decisions and, at the same time, to form a responsible investor who understands that investing is not only a way to earn a return but also can make a positive impact on the world when green investments are chosen. This study shows that studying students tend to be very rational and interested in contributing to greening the world; however, they are still hesitant to put their theoretical skills into practise and are more likely to provide theoretical support for green investments rather than actually invest. Respondents are grouped according to their potential investment behaviour. The proportions of groups are assessed using statistical inference with a precision of 95% that allowed to propose the method of deriving confidence intervals for each group estimation and, thus, making estimates both reliable and available as statistical estimations.

Keywords: investor behaviour; investor types; Generation Z; green investing

1. Introduction

Financial technology (fintech) is transforming the financial service industry at an unparalleled pace. The rapid development of financial technology and the accessibility of financial markets to non-professional investors have led to a large number of young people trading in shares. According to a study by BofA Global Research, Generation Z investors are seeking to take advantage of market opportunities and make quick short-term profits. The authors showed that they frequently trade, take more risks, closely monitor their portfolios, and develop other conventionally "bad" investment habits. Such habits are criticised by investment experts [1].

In recent decades, the field of financial theories, behavioural finance, has been widely studied by incorporating various psychological insights to find out howemotions, experiences, other people's behaviour, trust, and other psychological causes influence the behaviour of investors [2–4]. A research group investigated the effect of investment sentiments and risk on financial behaviour in financial markets, generally supported by

mathematical methods [5–8]. A large and growing flow of research is related to young adults and their financial behaviour patterns, in which two indications are seen: the importance of strengthening the level of financial knowledge of Gen Z and the peculiarities of their investment behaviour [9–15]. More recent research complements studies on financial behaviour by including green investment issues, highlighting internal and external factors that impact such phenomena [16]. One of the reasons influencing the choice of green investment products is the fear of climate change and environmental catastrophe, as well as particular values [17,18]. The whole positive surroundings, in a particular state, are also important, especially some legal aspects [19]. For the green investing performance of Gen Z, who highly values communication, the impact of social platforms is significant [20].

Generation Z is characterised by great consumerism, infantilism, and narcissism; is perfectly suited for digital transformation; and values sustainability in the most diverse dimensions [21]. In the investment process, Gen Z demonstrates a high level of self-confidence [13], but, when there is more information, its decisions become more responsible and sustainable [14]). Generation Z's investment behaviour in financial markets attracts many researchers and leaves a gap for future studies.

The aim of this paper is to identify the types of Generation Z investors according to their tendency towards rationality and to find out how these groups react to green investments. This article uses a systematic literature analysis, a questionnaire survey, and graphical data representation methods. The authors conducted a survey of Generation Z at the Vilnius Higher Education Institution to investigate the rationality of the behaviour of young non-professional investors in financial markets and to improve the education of students about financial literacy.

The rest of the paper is organised as follows. Section 2 presents the literature review, and Section 3 presents the methodological part and shows the structure of the survey. Section 4 describes the empirical results. Sections 5 and 6 provide a discussion and the conclusions.

2. Review of the Literature

2.1. Financial Behaviour Concept, Characteristics, and Directions

The main objective of any investor is to minimise risk and maximise return. This is in contrast to speculators in financial markets, who are willing to invest in risky assets in the short term, hoping to profit from the spread between asset prices. Investors are divided into professional and non-professional investors. Non-professional investors are investors who have less investment knowledge and experience. This category includes the majority of natural persons who invest. This paper does not analyse the difference between the concepts of speculation and investment. Buying and selling shares is treated as an investment, regardless of its time horizon. In addition, in this paper, the word investor is used as a synonym for an individual investor, and this concept is equated with the definition of a non-professional investor.

Behaviour is a key concept taken from scientific human analysis and added to financial theory. The first ideas on the intersection of economics and psychology can be found in A. Smith's *The Theory of Moral Sentiments* (1759), but classical financial theory does not rely on these insights and argues that many rational investors operate in an efficient market [22]. The classical theory states that an investor is rational, makes rational decisions, has access to complete information, does not rely on emotions and preconceptions to make decisions, is deliberately risk-averse, and operates in financial markets for their own benefit. The rational investor is adept at using statistical and analytical methods to assess the financial benefits of investments. In the 1970s, the science of economics was full of scientific discoveries from cognitive psychology, showing that real people are not completely selfish and do not necessarily behave rationally. According to theorists, people often rely on preconceptions and emotions, the nature of the information they receive, and their own experience, as well as the experiences of others. Theorists claim that the investment decision-making process is influenced by a number of subjective and objective

reasons. Statman and Caldwell defined behavioural finance as a descriptive theory of choice under conditions of uncertainty [23]. Behavioural finance is concerned with the mind of investors and its role in making financial decisions. Influential researchers who have contributed to the development of the field include Kahneman and Tversky, Thaler, Baker and Wurgler, J. Shiller, and others. Hence, behavioural finance is an interdisciplinary branch that incorporates knowledge of economics, finance, psychology, and sociology and emphasises that irrationality and feelings impact investors' decisions and the asset price. According to performed bibliographic analysis, the number of research articles analysing financial behaviour has been rising, demonstrating that behavioural finance represents an important area of research [24,25].

Research on financial behaviour can be found in scientific journals on both finance and psychology. The field of psychology looks even more closely at deviance and the relationships between personality types. According to personality psychology, personality plays an essential role in the decision of investor behaviour and influences investor decision making [4]. Kumar et al. examined the relationships among traits such as herding behaviour, overconfidence, loss aversion, and five personality types and presented a possible decision tree [2]. Giancola et al. used the General Ecological Behaviour Scale to test the attitudes of 146 healthy Italian late adolescents and their relations with the Big Five theory, in order to adopt more environmentally suitable behaviours [26]. Singh et al. performed a cross-sectional research design to collect responses from 847 individual investors using a questionnaire. The study findings suggested that conscientiousness and extroversion traits significantly influence behaviour biases. The findings also explained that neuroticism is associated with herding, disposition, and anchoring bias. The findings confirmed the moderating effect of risk tolerance on the association between personality traits and behaviour biases [27]. The analysis of financial behaviour and self-confidence was conducted in the family economics stream, emphasizing the importance of family wellness for appropriate financial behaviour [11,28].

According to Paule-Vianez et al.'s bibliometric research, some biases of behaviour finance can be divided into some directions. The largest group is related to investor sentiment, which covers the aspect of how an investor's feelings lead them to make certain investment decisions, which are far from the optimal decisions according to the theory of efficient markets. The disposition effect, related to the analysis of investor risk aversion and expected stock returns, concentrating on the analysis of the movements of asset prices based on investors' behaviour, is also very popular among researchers. Other smaller areas include topics related to studies about overconfidence, the effectiveness of certain stock market strategies, portfolio selection, etc. [25]. The bibliometric analysis and literature review of investor behaviour in cryptocurrency markets have defined several clusters: investor sentiment herding behaviour, momentum and investor attention, news effects, and crypto markets' efficiency studies [24]. Research by the authors reveals that stock returns are influenced by investor sentiment [5]. Investor sentiment behaviour highlights the moods of investors, particularly for a short period of time. The authors measure it by using different ratios. The empirical results of this paper show that overnight returns on the TWSE cause short-term persistence and long-term return reversal, both of which are driven by investor sentiment and, therefore, verify the validity of overnight returns as an investor sentiment proxy [6]. Based on the research by He et al., geopolitical risks have significant negative effects on investor sentiment, suggesting that higher (lower) geopolitical risks directly or indirectly dampen (promote) investor sentiment [29]. Researchers have attempted to measure investor sentiment using various methods, mostly including surveys [7,8].

Numerous studies have examined Generation Z to understand their financial behaviour. Song et al. investigated financial behaviour by studying the impact of financial literacy, financial risk tolerance, and emotional intelligence using answers from 389 financially independent individual investors from leading educational institutes in Pakistan. The study found a significant modulating role of emotional intelligence in the direct relationship between financial literacy and financial risk tolerance and an indirect relationship

between financial literacy and financial behaviour [10]. The relationship between financial behaviour and financial literacy is a popular topic, especially in developing countries, where the authors find a huge gap between people who have received financial education and those who have not [10–12]. In this study, financial behaviours are categorised in the context of short- and long-term behaviours. Financial satisfaction, assessed financial capabilities, and knowledge are directly correlated with financial well-being. Financial stress has a long-term negative impact on financial satisfaction [30].

Financial behaviour can be associated with some determinants, for example, financial knowledge, some psychological traits, and subjective perceptions. With the rise of environmental concerns and the need to educate investors by adding a green attitude, the perspective needs to be regularly updated and tested with different sample groups. There is still a gap in such studies related to the types of personality of Generation Z and their attitudes to assess environmental information before making an investment decision. What are the general psychological characteristics of the chosen sample of Generation Z based on their investment habits?

2.2. Green Investing—Concept, Investor Behaviour Sentiment, and Influencing Factors

Green investing (more generally, sustainable investing) is another research area that stands out because green investing is a priority part of the European Commission's Green Deal Investment Plan [31]. Researchers are looking for answers to the question of what could further encourage investors to choose responsible companies and, thus, contribute to transforming the economy. Anderson and Robinson carried out a survey consisting of four blocks of questions: financial and environmental literacy; green behaviour; investment awareness; understanding of climate disasters. The results showed that the choice of green investments is also driven by fears of potential catastrophes caused by the effects of climate change, leading to a change in investment portfolios, which is an incentive for green investment. More generally, the study showed that climate fears are much more strongly linked to everyday consumer behaviour and are much less transferable to financial actions. The authors noted that monetary motives are also an important part of investment choices, with some respondents believing that environmentally friendly investments are profitable. This indicated that monetary motivations are part of the decision to invest in green funds or are a way to rationalise these beliefs [17]. Wang et al. combined investor behaviour sentiment and green concepts [18,32]. The study investigated the relationships among environmental news, investor sentiment, and green industry stock returns in China. Regarding the effect of investor sentiment on stock returns, to determine the impact of online environmental news on the stock returns of green industry companies in China, this study developed an environmental awareness index for the media. The empirical results showed that environmental news had a significant effect on the stock returns of green companies in China, and investor sentiment played a partially mediating role in the effect [18]. This study provided another insight into the green financial market by highlighting the importance of environmentally friendly financial instruments [32]. Dhasmana et al. emphasised that investor sentiment does not play a role in the impact of the ESG index. This implies that ESG initiatives may not immediately attract positive sentiments but have a positive impact on investors in the long term. The authors compiled an investor sentiment index that includes the following variables: advances and decline ratio, buy and sell imbalance, trading volume, turnover volatility rate, initial public offers, equity issues in a total of equity and debt, market-to-book ratio of dividend payers and non-payer firms, put call ratio, fund flow, security lending, and borrowing [33]. Trust has become the key component to ensure sustainable capital among green initiative companies. Promoting trust among investors, personal attitude, subjective norm, and perceived behavioural control found positive influence on trust in green financial products [34]. Other authors argued that the success of green investments as a new hybrid practice is impacted by the state's approach and its legal situation. Shareholder protection policies complement green investment and the promotion

of environmental goals, presumably because, in these countries, the legitimacy of investors is higher, thus amplifying the normative or cultural influence of green investment [19]. According to Agrawal, with respect to Gen Z, the influence of social networks has a positive impact on green performance [20].

The reviewed studies showed that there are many questions when analysing the causes for green investment. The combination of personal types of attitudes towards green investing is very important and novel. After the analytical studies, the question arises—what is the attitude of Gen Z towards green investing?

2.3. Generation Z—Investment Profile

The word "generation" is a certain phenomenon widely used in society that allows us to understand the differences between different age groups. The distinction between generations based on the time of birth is not very precise, as most countries have a unique history and have been directly affected by different demographic, historical, and socio-cultural phenomena. However, most scholars take a simple approach and divide generations according to the date of birth of people, taking into account the main events of a given period. The pioneers of the generation theory, W. Strauss and N. Howe (1991), define the following generations: the Baby Boom Generation (1943–1960), Generation X (1961–1981), Generation Y/Millennial Generation (1982–2004), and Generation Z/Internet Generation (since 2005) [35]. Researchers point to different characteristics of Generation Z: hyperactivity, infantilism, consumerism, lack of concentration or attention, communication, and critical thinking. This generation does not like to be tied to static work in offices; it is characterised by a dynamic working style and multitasking [36]. According to E. Kocai, these young people today are characterised by disorientation, apathy, and conflict between acceptable values and those imposed on them by others, while consumption is becoming one of the most important foundations of their individual lifestyle [37]. Dolot argued that a characteristic feature of the Generation Z sample is that, despite their young age, they are already professionally active [38]. Hernandez de Menendez et al. found that Generation Z prefers to learn through new technologies, such as virtual and augmented reality, 3D printing, artificial intelligence, holograms, wearable technology, virtual laboratories, and the blockchain [39]. The behaviour of Generation Z investors in financial markets is of interest to many researchers. Chen et al. argued that, although Generation Z has qualities such as creativity, receptiveness to information, and the ability to multitask, it is impatient and want quick solutions: it is result-orientated rather than process-orientated and does not like long, monotonous activities [3].

In the literature, this generation is considered to be more environmentally conscious and is green and willing to pay more for eco-friendly products [40,41]. The study showed that Gen Z is a generation that wants to feel personally connected to sustainability ideas [42]. It was found that environmental concerns positively influence the willingness to pay more for green products by consumers of Generation Z. Generation Z also expects retailers and brands to become more sustainable [20]. Digital natives, with a sense of equality, social justice, and environmental awareness, people from Generation Z value money more than previous generations and, as such, are conscientious in their consumption choices. The results showed that environmental concerns, the estimation of the future being green, and the perceived quality of green are potential determinants of the consumption of green products by Generation Z and positively influence the willingness to pay more for green products [21]. Social media and its effect on the green practices of Gen Z guides businesses and marketers in promoting their green initiatives [20,42].

In their research, Rosdiana identified a very high level of self-confidence as a key characteristic of the investment decisions of Generation Z. This suggests that only a high level of investment capacity can lead to efficient, well-considered, and unhurried investment decisions [13]. Philippas and Avdoulas conducted a survey of Greek students (2019–2020), and the analysis revealed that the more information young people have, the more responsible their decisions are, which is why it is important to understand their attitudes towards

investing and develop them. The authors found that male students are more financially literate than female students. Their findings show that students who are more financially literate are better able to withstand unexpected financial shocks [14]. Artavanis and Kara examined the level of financial literacy of US students (University of Massachusetts) and its impact on the repayment of student debts. They observed low levels of financial literacy (39.5%), especially among female students (26%) and first-generation students (33%) [15]. Furthermore, students with financial literacy deficiencies are more likely to underestimate future student loan repayments, and up to 38.2% of low-literacy students underestimate future risks. The authors noted that students with lower financial literacy expect to earn lower salaries in the future. Gedvilaite et al. combined two concepts, financial literacy and sustainability knowledge, in order to test the attitudes of Generation Z in the three Baltic countries (2021) and found that the sustainability knowledge level is equal in these countries [9]. The majority of Polish respondents from Generation Z also stated that the implementation of the CSR concept in an organisation is an important factor in deciding whether to invest capital [16].

The key characteristics of Gen Z are that it values money, is impatient, and relyies on technologies, but it also values sustainability ideas. What are the attitudes of Gen Z towards green investment and how are these related to psychological patterns?

The current research contributes to the financial behaviour theory by examining how personality factors affect behaviour biases. The existing literature on behaviour finance stated that the investment decision-making process is based on a complicated mix of personal characteristics (personality traits, risk tolerance, emotions, etc.) ([43,44]) and demographics (i.e., gender, age, education level, etc.) [45]. This research focuses on studies that combine financial behaviour theories, the green approach, and Generation Z's particularities. This article emphasises the problematic question of what types of investors Generation Z tends to be. The results might improve the process of learning about and consulting on investing, taking into account the characteristics of Generation Z and personality types. The significance of the green economy in financial markets inspires the inclusion of additional questions to investigate Generation Z's attitudes towards green investing and, at the same time, to stimulate more interest in it.

3. Methodology

In order to investigate the behaviour of Generation Z investors in financial markets, the Pompian MBTI model was chosen [46].

There are many articles in psychological journals [2,4,26] that combine the special set of personal characteristics and particular financial behaviour. Such studies lead to better understanding of various internal determinants and help in self-assessment and decision-making understanding, as well as in improving consulting and teaching processes. The Pompian model was chosen as the very clearly systemised methodological approach suitable for the first exploratory research. Furthermore, the method is very useful for promoting smart educational processes by incorporating self-assessment.

Pompian argues that some investors have little time and patience to manage their finances, others start investing too late, and some show more discipline in investing in the financial markets than others. The model of M. M. Pompian identifies eight possible types of investor personalities based on the three dimensions of the investor personality profile. The Pompian MBTI model and the questionnaire survey research method were applied to investigate the behaviour of Generation Z students studying at the Vilnius Higher Education Institution who invest in the financial markets.

The survey questionnaire consisted of 15 diagnostic questions divided into three blocks of five questions each, according to the personality dimensions of investors. The questionnaire was designed using closed-ended questions. The first block of questions was designed to determine whether the investor is an idealist or a pragmatist (I or P) according to their personality profile. The second block of questions identified whether the investor is a framer or an integrator (F or N), and the third block of questions asked whether the

investor is a reflector or a realist (T or R). The letters in the Pompian model represent the good and bad characteristics of investors. The bad characteristics, i.e., irrational behaviour in financial markets, are typical of the idealist (letter I from the first dimension), whose main distinguishing features are overconfidence and a reluctance to seek out more information; the framer (letter F from the second dimension) is characterised by attachment to certain information and reluctance to analyse external factors. The reflector (letter T from the third dimension) is characterised by fear and reluctance to take proactive action. Conversely, the pragmatist (letter P from the first dimension) has good qualities, i.e., rational behaviour in financial markets, demonstrates a good understanding of reality and of oneself, and tends to extensively analyse. The integrator (letter N from the second dimension) is characterised by a systematic approach and the ability to structure their portfolio. The realist (letter R from the third dimension), unlike the reflector, has the courage to make decisions. Following the questionnaire survey and the analysis of the responses of the respondents, in order to identify the predominant trait in each of the three dimensions, eight three-letter acronyms (IFT, IFR, INT, PFT, INR, PFR, PNT, and PNR) were created, indicating the combination of traits that to the classification of the investor in one of the eight investor personality types. This model was supplemented with questions on green investment propensity to determine which types of students were more likely to consider the environmental impact of their financial decisions.

The study population consisted of all students of the Faculty of Electronics and Informatics, Faculty of Economics, and Faculty of Business Management of Vilnius Higher Education Institution, born in 2000 and later, i.e., 2446 students in total. The survey questionnaire was sent to students at Vilnius Higher Education Institution by e-mail. The MS Office 365 Forms package was used for the survey, and the obtained data were processed in MS Excel. The survey was carried out between February and March 2023.

The initial decision for error with a statistical precision of 95% was to keep it close to 5%, resulting in a sample size estimate of 273 cases, where the maximum variance of the binomial distribution was reached with probability. After this prior estimation and collecting and, finally, discarding invalid responses, we obtained a satisfactory number, n = 379, of valid responses for cases of a smaller proportion of the responses than 50%, as the smaller proportion further decreases required n for the error chosen. Frequencies of the types were gleaned in numbers and converted to percentages. Due to the stochastic character of answers, for making extended generalisations about population of students with similar characteristics, we decided to solve a problem of estimating the error for the obtained proportion of responses. Responses were structured in a way that belonging to each dimension of the students were read in the Boolean format; therefore, the binomial distribution could be applied for description of the whole population of similar students in terms of a percentage of a particular dimension within the population, with probability of success equal to the percentage rate of positive responses. The dispersion is known to be equal to the product of the probability of success and failure. Inference relates to stochasticity, and, therefore, it needs additional exploration in terms of reliability of qualitative interpretation. We used the above-described parameters for estimation the error margin, e%, for each dimension with a precision of 95% and for the number of valid elicited responses. The formula for such estimation was derived by substitution boundaries of 95% probability interval of the standardised normal distribution (which is asymptotic to the binomial one), to the following formula of required number of respondents [47,48]:

$$n = \left(\frac{Z_\alpha}{e}\right)^2 S, \tag{1}$$

where α is the confidence level; Z_α is the boundary of the standardised normal distribution that cuts the zone of probabilities around zero of the chosen reliability of the statistical model; S is the estimation of dispersion from the sample; and e is the acceptable error expressed in percentage that expresses the boundary of the confidence interval.

Confidence intervals are, therefore, derived using the previously described parameters in accordance from the modified Formula (1).

$$e = Z_{\alpha}\sqrt{\frac{S}{n}}, \tag{2}$$

Such errors of inference represent boundaries of confidence intervals; they are shown in Figure 1. Analysis of the results can be carried out based on exact percentage numbers elicited from responses because statistical confidence appears to be rather moderate: up to 4.23%.

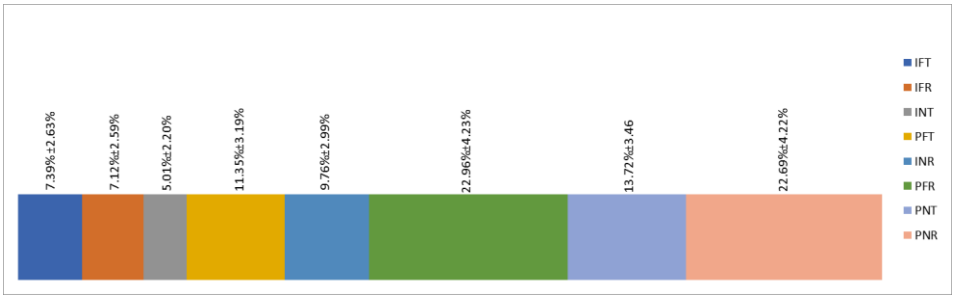


Figure 1. Proportions of dimensions of the investor personality profiles among students and errors of inference.

Proportions shown in Figure 1 reveal the structure of investors by personality dimensions and lead to the following results and conclusions. Assessment of the general preference of all respondents towards green investment is made by testing the following statistical hypothesis:

H0. *Students are not inclined to be in favour of green investment.*

H1. *Students are inclined to be in favour of green investment.*

The limitations of this study are that the results were obtained from one country and one educational institution. The data cover the respondents referring to Generation Z from two faculties—economics and electronics. Students in both faculties have enough knowledge to manage investments. To secure anonymity, the decision not to collect data based on gender was confirmed.

4. Results

A comparative theoretical analysis between Generation Z's theoretical traits and those presented by M. M. Pompian shows that researchers attribute more traits from the negative traits scale (idealist, framer, and reflector) to Generation Z and that this is in line with other studies [3,13,37]. Overoptimism and self-confidence make them similar to idealists, and they are not inclined to think much about external actions, relying on what the situation looks like at the time, like framers, and trying to rationalise decisions that are not always correct, like reflectors. The questionnaire survey aims to observe the predominant characteristics among current students as current and potential investors.

It is important to note that not all of the respondents claimed to have no experience in investing and answered the questionnaire by imagining they were investors. A lack of funds is one of the reasons why students studying these subjects do not actively try real opportunities, but a lack of self-confidence may also play a role.

The visualisation of the distribution of personality types of investors, as presented in Figure 1, could be used to perceive the proportions of the combined dimensions of more general personality types. Overall, 46.5% of the respondents belong to the group of "good" investor personality types (INR, PFR, and PNT types), which are more rational,

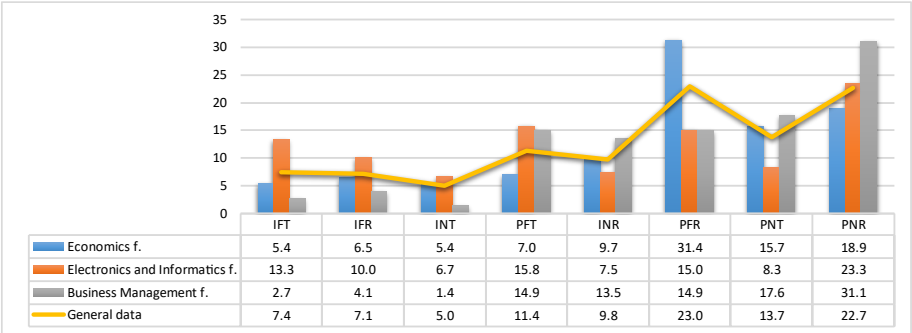
and 22.7% are "excellent" (PNR type), according to Pompian's model. And only 24% need improvement (IFT, IFR, INT, and PFT types). Almost a quarter of them belong to the pragmatist/framer/realist (PFR) investor personality type.

Similar to above, the errors of inference or boundaries of confidence intervals that estimate the magnitudes of each group with a precision of 95% are as follows: e = 5.02% for the group that comprises the INR, PFR, and PNT types; e = 5.02% for the group that comprises the INR, PFR, and PNT types; e = 4.30% for the estimation of the magnitude of the group of the IFT, IFR, INT, and PFT types, while inference error margins for the group PNR and the group PFR type are shown in Figure 1.

Among respondents with more rational behaviour, the personality type of pragmatist/framer/realist (PFR) for the investor is among the most dominant (see Figure 1). A further 23% of respondents have fully rational investment behaviour (PNR investor personality type). And 31% of respondents need to improve their behaviour in financial markets because their behaviour is irrational (IFT, IFR, INT, and PFT investor personality types combined). Even students who are studying such pragmatic programmes (social and technical sciences) have some irrationality in their behaviour in financial markets. The inference error margins for such groups are provided above.

Initial observations are provided based on responses within each group, although similar estimates of reasoning errors cannot be made due to the small number of group members; however, we intend to increase the group of respondents in future studies and provide better estimations.

The personality type PNR, described by Pompian as an excellent type with reasonable behaviour, is shared by 31.1% of students in the Business Management faculty (Figure 2). The highest scores are 18.9% from the Faculty of Economics and 23.3% from the faculties of electronics and informatics. Students from the business management faculty tend to have the most favourable opinions towards rational behaviour in the financial markets, which supports the logical conclusion that these kinds of studies may have a significant influence on more rational behaviour.



	IFT	IFR	INT	PFT	INR	PFR	PNT	PNR
Economics f.	5.4	6.5	5.4	7.0	9.7	31.4	15.7	18.9
Electronics and Informatics f.	13.3	10.0	6.7	15.8	7.5	15.0	8.3	23.3
Business Management f.	2.7	4.1	1.4	14.9	13.5	14.9	17.6	31.1
General data	7.4	7.1	5.0	11.4	9.8	23.0	13.7	22.7

Figure 2. Distribution of investor personality types by faculty.

Therefore, this exploratory study reveals that Generation Z respondents tend to be rational investors, similar to the results of a study conducted by Bikas and Kavaliauskas, which surveyed Lithuanian investors (in this study, the majority of respondents were from the older generation) [49]. However, it should be remembered that these are students of the Faculty of Economics, and, according to many researchers, more rational decisions are made by those who have more financial knowledge [3,13,14].

Generation Z is described by many scholars as a materialistic generation, with a strong consumerist streak, as was also presented in [21] but with an appreciation for sustainable ideas confirmed by other studies [16,40–42]. According the research's results (are shown in Figure 3), the majority (75%) of the respondents feel responsible for the impact on the Earth's climate and the negative effects of climate change on the planet and on people. Also, 72% of the respondents believe that a decision to invest in the shares of sustainable companies that have chosen to go green can have a positive impact on the future of the

planet. Almost half (48%) of the respondents would invest in green technology companies because they believe that the sector is promising and that the company's choice of a green course is in line with their approach to responsible investment. In addition, 53% of the respondents say that they would consider investing in green companies' shares after the survey, while 12% say they are already choosing green investments.

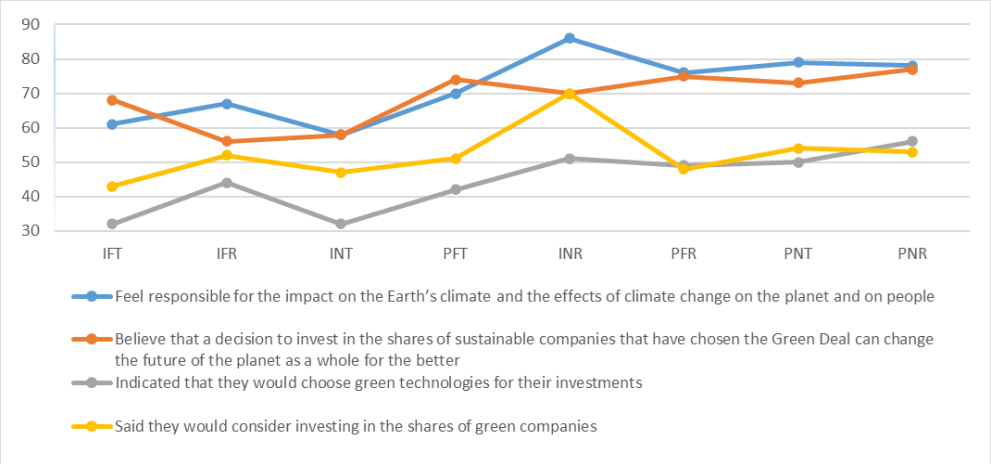


Figure 3. Green investment preferences by type of investor personality (%).

The analysis of the survey results provides possible links between the personality types of the identified investors and their propensity to green invest. The relation between investor types and green investment preferences can be observed in Figure 3.

Students with the idealist/integrator/realist (INR) investor personality type are the most likely to green invest. As many as 86% of this type of investor indicate that they feel responsible for the impact on the Earth's climate and the effects of climate change on the planet and people. Also, 70% of this type of investor believe that investing in sustainable green companies can change the future of the planet for the better, and they are investing now or plan to do so in the future. In addition, 51% of the respondents belonging to the INR investor type say that they would invest in green technology companies because the companies' choice of a green course is in line with their approach to responsible investment. However, 35% of this investor type still believe that investing is all about maximising returns and would, therefore, choose potentially more profitable stocks, regardless of the company's choice of exchange rate. The INR investor type is characterised by high self-confidence, broad-mindedness, and courageous decision making.

The survey shows that idealist/integrator/reflector (INT) investor personality-type students are the least likely to think about green investments: 58% of this investor personality type feel responsible for the impact on the Earth's climate and the effects of climate change on the planet and on people, while 32% indicate that they would choose green technologies for their investments; 47% of students of this type indicate that, for them, earning the highest possible return is the most important goal, regardless of the nature of the company's activities, so they would choose to invest in a company whose shares have a better chance of generating a higher return.

All responses to the four questions outlined in Figure 3 make a total of 740 answers, while the number of positive responses in the sample make 496 in total. This makes 67% of the responses positive. The standard deviation of the mean of such replies makes up 1.73%, calculated by using the formula for the standard deviation for the mean of a binomially distributed random variable expressed as a percentage. The difference between the mark of 50%, which would mean perfect indifference, and 67% is much greater in terms of such standard deviations than the right-hand side threshold of the standardised normal distribution for a 95% probability, which is 1.645. We, therefore, can reject hypothesis H0,

with the stated degree of statistical precision, and claim that the students of Generation Z have a propensity for green investment.

Despite the fact that most students feel responsible for the impact on the Earth's climate (blue line on the graph), they mostly think about it and consider it, instead of actually being ready to choose green investments at the moment (grey line). In this case, there is a scope for further study on green investments. Better psychological knowledge leads to a more realistic perception of oneself and the world. Analysing fears and influences and channelling them towards positive goals can facilitate decision making and increase financial well-being, as well as more effectively contribute to the green transformation. Hence, it is clearly seen that Generation Z sympathises with a sustainable world, and this notion was confirmed by many other studies [16,20,21,42]; the rational basis to choose faster profit is also very strong, as other authors noticed [36,37]. However, it should be remembered that the more Generation Z knows about environmental economics and improves their sustainability and financial literacy, the more they are responsible consumers and investors [9,14,19,21,34].

5. Discussion

The growing concern about the rapid environmental degradation impact increases the attention to the green concept at investment levels. The transformation of investment patterns, which has only been orientated to make profit in the early days, should include environmental risk. Generation Z, whose attitude analysis is very important for practitioners and politicians, will soon be leaders. First, the results of research provide a better understanding of the existing academic literature on young investor behaviour, consolidating its knowledge, and identifying gaps to facilitate future studies; second, this study provides valuable research findings for investors, academics, policymakers, businesses, professionals, and society. The assessment of Generation Z investment patterns often falls under the concepts of finance and psychology. Researchers' have conducted surveys of students, and their research shows that the more information young people have, the more responsible their decisions are, which is why it is important to understand their attitudes towards investing and to nurture them, which is in line with other studies [9,14,19,21,34].

We suggest that green attitudes should be encouraged, and such behaviour fosters ecological well-being. Generation Z is keen to be more sustainable [16,20,21,42], but, in many cases, short-term profit impacts its real decision [36,37]. Our results show that positive attitudes towards the green economy are often not linked to actual actions.

Limitations of the Study

Most students of economics know what the correct answer should be according to the theoretical approach being taught, and this may have introduced bias into the survey responses. In the future, the survey will be expanded to include more students from other fields, with a subsequent comparison of their responses. Another direction can be the analysis of comparing survey results and the real situation and what factors impact mismatching.

Assuming that the accuracy of the model estimating the size of investor personality profiles was achieved by using statistical inference for the elicited 379 valid responses, for the binomial distribution with the probability parameter equal to the percentage of individuals with a particular dimension, and by taking a reasonable level of statistical precision of 95%. The number of responses represented a large part of the above-described population of students and, therefrom, produced moderate inference errors. Consequently, it is probable that the derived proportions represent the corresponding population well in terms of the dimensions of the investor personality profile. The probabilities in the binomial distribution are quite strongly divergent from 0.5; consequently, the hypothesis about the propensity of the students towards green investment is formulated and accepted. The sizes of each dimension appear to be too small for estimating the precision of the responses within each group; consequently, this investigation will be extended in future studies.

The limitation is that the sample includes only one educational institution and only one country. Expanding the sample to different countries and having a broader comparative analysis can enrich the results and impact.

6. Conclusions

Classical financial theory states that investors operating in an efficient market are rational. Rational investors in financial markets seek to maximise their own financial gain by using their analytical skills. However, experts in cognitive psychology dispute this, arguing that individuals do not always behave rationally. Investors' decisions are often influenced by emotions, preconceptions, personal experience or the experiences of others, and other psychological reasons; therefore, researchers in this field classify investors into types according to the factors that determine their behaviour. Research on cognitive psychology confirms that some non-professional investors behave irrationally in financial markets, which reduces their wealth and negatively affects their financial performance. Irrational behaviour in financial markets is also a characteristic of Generation Z due to the characteristics attributed to them, such as a lack of patience, a desire for quick solutions, an intolerance of monotonous and consistent activity, and excessive self-confidence. Each generation is unique, with positive and negative traits. The positive thing is that the life of Generation Z is much more dynamic: they are quick at decision making, good at managing information, and active in investing thanks to their excellent use of investment apps. Materialism or consumerism can be mentioned as a negative characteristic of Generation Z. It is a materialistic generation that pays a lot of attention to brands, chasing fashion and innovation.

According to the Pompian scale and theoretical research on generations, it was observed that Generation Z has more problematic traits (idealist, framer, and reflector), which have to be improved during educational and consulting procedures. It was hypothesized that, according to the general characteristics, the representatives of Generation Z can be classified as a group of personalities that are less rational. However, this was not observed during the study of VIKO students. This study showed that most of the students in the study behave rationally in financial markets, while only a small proportion of them are more likely to rely on emotions and other psychological factors when investing. The results by type of investor showed that Generation Z has relatively good investment skills and intuition. Many students demonstrated pragmatist qualities, such as a good understanding of reality and themselves, and the ability to justify actions through analytical analysis. Only a small proportion (24%) of them fell into investment types whose overoptimism and self-confidence still need to be reduced. Their technical and social studies, which are based on a logical approach, may also have an impact on these results. The Faculty of Business Management was found to have the most favourable attitudes towards rational behaviour in financial markets.

An additional study aimed to identify students' attitudes towards green investing. Most of the study students felt responsible for the individual impact of each investor on Earth's climate and the effects of climate change on the planet and people and are, therefore, inclined to invest in green securities; however, there was a significant gap between their understanding and their actual willingness and commitment to do so. Overall, 86% of the INR cluster have felt responsibility for their investment decisions' impact on the global environmental state. Hence, as they are rational enough investors, 35% of them still believe that they should choose potentially more profitable stocks.

This article's findings expanded financial behaviour studies by combing psychological analysis and the attitudes towards greenness of Generation Z. It confirmed that, in addition to Generation Z's sympathy for sustainability, it is not very quick to choose green investments.

Our results showed that Generation Z could be more responsible in its actions, as its affinity for sustainability should be confirmed by its green investment choices. In contrast, policy makers should improve education curricula to make green and/or sus-

tainable subjects compulsory in all subjects taught. Expanding such a kind of research to other countries could add a broader comparison of the cultural aspects. It would also be of great interest for further research to involve researchers from psychological fields to explore the links between the various attributes and the actual actions that influence ecological transformation.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

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Green Human Resource Management: Practices, Benefits, and Constraints—Evidence from the Portuguese Context

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Abstract: In recent decades, the issue of environmental sustainability has become increasingly important worldwide and there is growing pressure from stakeholders for companies to transform themselves in order to mitigate their environmental impacts. Green Human Resource Management (GHRM) plays an important role in promoting a corporate culture of environmental responsibility, ensuring the effectiveness of companies' environmental strategy through its direct role with employees. In response to the lack of studies on GHRM and its implementation in the Portuguese business context, this study aims to map the GHRM practices implemented by companies operating in Portugal and to identify the perceived benefits, constraints, and challenges in implementing these practices. A total of 15 semi-structured interviews with human resource managers and environment-related management professionals of companies selected from an Environmental Management Systems—ISO 14001 database were conducted. The results show that organizations in Portugal implement environmental practices that fall within the scope of GHRM. The practices identified also range across transversal categories such as digital, mobility, products and waste management, infrastructure, performance, production, and corporate events. However, a holistic approach is needed and GHRM should be built under a multidimensional and well-planned system. This study argues that perceived benefits are constrained by the specific characteristics of the Portuguese business context which results in obstacles for the implementation and success of GHRM practices. The implications of the results for the organizations are discussed and suggestions are put forward.

Keywords: environmental sustainability; Green Human Resource Management (GHRM); practices

1. Introduction

In recent decades, environmental concerns have gained increasing importance on a global scale, and it is no overstatement to say that it is one of the key issues of our time, emphasized by the significant increase in natural disasters associated with climate change that are being felt across the globe. The issue of environmental sustainability emerged with the United Nations Conference on the Human Environment (or Stockholm Conference), which took place in 1972 and was defined as the start of an international political debate on environmental issues [1]. The concept of sustainable development itself first appeared at the World Commission on Environment and Development (also known as the Brundtland Commission) in the 1980s, in which development was defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs [2].

Since the emergence of the concept, there has been an exponential increase in pressure for action in favor of environmental sustainability on critical political and private decision-makers, and it is considered one of the central focuses of decision-making by managers in the 21st century [3].

This study focuses on the environmental responsibility of companies and the predominant role that Human Resource Management can play in achieving the green objectives that companies set themselves [4]. Stakeholders are increasingly paying attention to companies' environmental performance, which means companies must reinvent themselves to achieve their environmental goals [5]. If we consider the Sustainable Human Resource Management concept, Ehnert et al. define it as "the implementation of HRM strategies and practices that enable the achievement of financial, social and ecological objectives, with an impact inside and outside the organization" [6] (p. 90). This view suggests that there is more significant potential in people management policies than in purely financial objectives and results can go beyond a strategy based on numbers. Consequently, how organizations are dealing with the issue plays a prominent role in effective environmental management that results from a Green Human Resource Management strategy [7,8]. This approach, which brings the topic of environmental sustainability to Human Resource Management, is fundamental since HRM can influence the organization's relationship with its external environment, namely with society and the environment [9]. Green Human Resource Management, on which this investigation focuses, uses Human Resource Management procedures to encourage using assets within organizations to promote environmental sustainability [10]. In effect, GHRM allows companies to achieve tangible benefits beyond improving the image and strengthening the brand among stakeholders by enhancing the creation of new products and implementing new processes and policies that generate more productivity and ensure organization compliance [11]. In this context, human resource managers assume a significant role, as they are responsible for raising workers' awareness of the green movement, promoting the sensible use of resources, and helping organizations take a responsible environmental stance towards future generations [12]. In response to the lack of studies on GHRM applied in the Portuguese business context, the object of study is, firstly, to identify Green Human Resource Management practices applied in companies operating in Portugal. At the same time, we intend to identify the benefits these companies associate with GHRM, as well as the constraints and challenges they identify in implementing green practices, through the perspective of Human Resource Management professionals and those responsible for the companies' environmental sustainability.

The main aims of the current study are to (i) identify Green Human Resource Management practices in companies operating in Portugal that have environmental management system certification, specifically the ISO 14001 standard; (ii) identify transversal environmental sustainability practices in companies in Portugal with the ISO 14001 standard; (iii) identify benefits, constraints, and challenges companies associated with GHRM from the perspective of their Human Resource Management professionals and those responsible for environmental sustainability.

To respond to these objectives, the present study was based on a literature review performed to identify environmental sustainability practices and whether GHRM, more specifically, is being implemented at a global level to understand the Portuguese national reality better. After this literature review, a qualitative analysis was conducted on 15 Portuguese companies using the interview technique, followed by data analysis that allowed us to draw relevant conclusions. It was decided to focus on national companies certified with the ISO 14001 standard. The option for this inclusion criterion was understood as a factor that guarantees concern and application of environmental measures by organizations, constituting a solid basis for implementing GHRM [13].

To pursue these objectives, we adopted the perspective of Renwick et al. [14] who, based on the AMO theory of Appelbaum et al. [15], propose the analysis of GHRM based on five fundamental areas of HRM: (i) green recruitment and selection, (ii) green training and development, (iii) green performance management, (iv) green remuneration and benefits, and (v) green involvement and empowerment, which we will call green organizational culture, justifying this redefinition later.

The relevance of this research is significant considering the relative scarcity of studies in this specific area—GHRM—and in the Portuguese context. Additionally, there is no

knowledge of the existence of Portuguese studies that identify the direct or indirect impact of GHRM at the levels of the worker, company, and society, so we intend to explore experts' perspectives on the benefits that GHRM brings at the three levels mentioned, as well as the associated constraints and challenges.

The concept of Green Human Resource Management is still relatively new in research despite the considerable increase in studies in the last decade, which means that the impact of GHRM in the work context requires more in-depth empirical work and studies [16]. Therefore, it is possible to affirm that the object of study, in addition to its evident environmental relevance, has scientific, social, and economic significance. At a scientific level, it can be considered relevant, as it adds relevant information and enriches the empirical analysis in this area. At a social level, it is relevant in that there is great interest from interested parties, particularly society in general, in environmental sustainability, with the association with green practices being important for the organizations and individuals that make them up. Finally, at an economic level, this research is essential because consumers are increasingly paying attention to environmentally friendly practices.

1.1. Literature Review

1.1.1. Concept of Green Human Resource Management (GHRM)

The emergence of the concept of Green Human Resource Management has been associated by several authors, with Wehrmeyer [17] and his work "*Greening People: Human Resources and Environmental Management*" [18–22] bringing environmental management and Human Resource Management together for the first time.

This close relationship between the concept of GA and HRM was adopted by the scientific community in the following decades [14,19,23,24], reinforcing the importance of GHRM, since it is argued that HRM improves the environmental performance associated with GA [8,25,26].

In the literature, some distinct views also incorporate the social scope in understanding GHRM [27–29]. However, for the present research, understanding GHRM with a focus on the environmental dimension was assumed to be privileged. In other words, although the literature has been analyzed simultaneously in both fields [30], in this study, we will outline the analytical perspective that assumes the concept of GHRM relates only to aspects of environmental management and Human Resource Management. We therefore consider it essential to distinguish the two concepts—Sustainable HRM and GHRM—analyzing Sustainable Human Resource Management as an HRM specialty and a framework that guides the concept of GHRM [30]. Sustainable HRM is defined as "the management of human resources [that seeks] to satisfy the ideal needs of the company and community of the present without compromising the ability to meet the needs of the future" [31] (p. 910). In our understanding, this concept is a broader concept of "sustainability", formally used in the Brundtland Commission in 1983 [2]. Sustainable HRM refers to the Triple Bottom Line [32]—People, Planet, and Profit, based on social, environmental, and economic performance, respectively.

In turn, GHRM is "a type of Sustainable HRM that focuses on environmental problems" [33] (p. 76) and that seeks to achieve the objectives of environmental performance, waste reduction, and competitive advantage, assuming a process of constant improvement and innovation, and total integration between green objectives and strategies and organizational objectives and strategies [14].

1.1.2. GHRM Areas

The role of GHRM in environmental management and the green commitment of organizations involves careful planning and internal processes aligned with the organizational strategy [14]. To this end, it is important to consider the areas of Human Resource Management with relevant impact on environmental management. Although most HR functions may have an inherent green component, contributing to the organization's sustainability [34], this study focuses on five major areas of HRM, following the organization

of other authors, such as the work of Renwick et al. [14] who propose the analysis of GHRM based on five fundamental areas of HRM: (i) green recruitment and selection, (ii) green training and development, (iii) green performance management, (iv) green compensation and benefits, and (v) green involvement and empowerment, which we will refer to as green organizational culture.

Table 1 was prepared to identify the HR functions that integrate these major areas and a descriptive synopsis to better understand the adopted areas and what they refer to in this study.

Table 1. Organization of HR functions by GHRM areas.

Classification of Adopted Areas	Author(s)	What Comprises This Area	Function Classification	Author(s)
Green recruitment and selection	Renwick et al. [1]	Job description with environmental dimensions Job advertisements with the company's environmental values Selection of candidates with a pro-environmental stance and with environmental knowledge to correctly conduct the functions	job design	Arulrajah et al. [7]
			job analysis	Arulrajah et al. [7]
			job description and analysis	C. Jabbour et al. [25]
			human resource planning	Arulrajah et al., C. Jabbour et al. [7,25]
			recruitment	Arulrajah et al., C. Jabbour et al. [7,25]
			selection	Arulrajah et al., C. Jabbour et al. [7,25]
Green training and development	Renwick et al. [1]	Environmental training programs and good practices	training and development	Arulrajah et al., C. Jabbour et al. [7,25]
Green performance management	Renwick et al. [1]	Integration of green criteria in evaluations of workers' professional performance Implement rules of conduct related to ecology and hold workers and managers accountable	performance evaluation	Arulrajah et al. [7]
			discipline management	Arulrajah et al. [7]
			performance management	Tang et al. [35]
			performance appraisal	C. Jabbour et al. [25]
Green compensation and benefits	Renwick et al. [1]	Monetary and non-monetary incentives for workers who have achieved environmental goals	reward management	Arulrajah et al. [7]
			rewarding and compensation	C. Jabbour et al. [25]
Green organizational culture	adapted from Renwick et al. *involvement and empowerment* [1]	Sharing green values between organizations and workers Formal and informal internal communication related to the environment Create green working environments Promote opportunities for worker participation in the environmental strategy, identifying the union and relationship between managers and workers as a key element	socialization	Shahriari and Hassanpoor [22]
			health and safety management	Arulrajah et al. [7]
			participation and working relationships	Ahmad and Nisar [36]
			employee relations	Arulrajah et al. [7]

Green Recruitment and Selection

We can understand green recruitment and selection as attracting talent sensitive to environmental causes generated through paperless practices [37]. This area comprises

three fundamental aspects [35,38]: (i) green worker awareness, (ii) employer branding, and (iii) green selection criteria.

The green consciousness of the workers concerns the personality of the candidates and their pro-environment consciousness, which internally enhances the voluntary behaviors of organizational citizenship for the environment at the individual level, which are not recognized by the formal reward system and contribute to a more sustainable organization [39].

Green employer branding, comprehended as a company's image and environmental reputation, is increasingly a differentiating factor in attracting talents sensitive to environmental causes. These are increasingly attentive and evaluate the environmental performance of companies, giving preference to those that present themselves with a positive environmental impact, being consonant with the values of the candidate and those of the company [40].

Finally, concerning green selection criteria, some authors argue that companies should recruit candidates who are familiar with or have environmental skills [7,41], emphasizing environmental aspects in job descriptions and candidate requirements or dedicating some questions on the environmental topic in the interview phase, shortening the lists of candidates selected based on these criteria [42]. Several authors have identified some green recruitment and selection practices, which we identify in Table 2:

Table 2. Green recruitment and selection practices.

Green Recruitment and Selection Practices	Author(s)
Online job description	Deshwal [43]
Inclusion of the company's environmental values in job advertisements	Arulrajah et al., Bombiak and Marciniuk-Kluska [7,34]
Reception of online CVs through platforms	Deshwal [43]
Use of internal job portals that allow access to job application documentation (offer letter, certifications, references)	Deshwal [43]
Verification of environmental knowledge and skills of candidates in the recruitment process	Bombiak and Marciniuk-Kluska [34]
Integration of the environmental dimension into the job description of each position, namely the inclusion of ecological skills as transversal skills for all jobs (tasks and responsibilities)	Mehta and Mehta [4]
Creation of new jobs that dedicate themselves to the organization's environmental management	Mehta and Mehta [4]

Green Training and Development

Green training and development is the set of activities that allow for learning environmental skills and raising workers' awareness of this cause [38], promoting a reduction in waste consumption, the use of adequate resources, and energy conservation, and reducing the causes of environmental degradation [44]. This area of GHRM must be understood considering three fundamental aspects, according to Tang [35]: (i) improving green awareness, (ii) green knowledge management, and (iii) development of a green climate. Thus, in addition to promoting awareness of the problem among workers, allowing, e.g., knowledge about the environmental impact that the organization generates in its activity [45], it enables them to achieve environmental management goals [46] and build a green climate that involves workers in these initiatives.

The literature suggests that this practice should be applied extensively, meaning it should reach all workers, not just those with connections to environmental management departments [38,47]. This broader scope is often considered crucial for the success of the results [48,49], as it promotes the involvement and motivation of workers in solving environmental problems [44].

In the conducted research, we identified practices of green training and development, which we present in Table 3:

Table 3. Green training and development practices.

Green Training and Development Practices	Author(s)
Implementation of environmental management programs to train workers and develop required skills	Arulrajah et al. [7]
Analysis and individual identification of workers' ecological training needs	Arulrajah et al. [7]
Distribution of surveys to workers to determine their level of literacy on the topic	Milliman and Clair [50]
Holding seminars and workshops to create environmental awareness among workers	Renwick et al. [21]
Creation of a job rotation system to train environmental issues in practice	Renwick et al. [14]
Promotion of environmental education among managers and their teams to encourage a change in attitudes and behaviors	Arulrajah et al. [7]
Organization of competitiveness programs that instill environmental values among workers, involving their families	Saifulina et al. [9]

Green Performance Management

Green performance management systems are a continuous process in the organization that will allow individual performance to be periodically evaluated to guarantee the achievement of the company's strategic objectives [11]. It is crucial that these systems are aligned with the company's environmental strategy [36] and that there is a connection between the performance evaluation criteria and the individual tasks and objectives described in the roles that each worker occupies [51,52]. Organizations have different structures and resources, so measuring green performance through standardized measures is ineffective [53]. It is, therefore, important to identify a systematic method of implementation through key performance indicators (KPIs) that include green goals [52], considering different types of organizations [38]. Clarity in performance assessment indicators is key [38], and their criteria must include factors of influence of managers within their teams, namely in the way they create awareness and involvement in environmental issues [36]. Managers must, therefore, be encouraged to incorporate environmental objectives into the functions of their teams, making them responsible for monitoring results and environmental reports [54]. It is necessary to include issues such as environmental incidents, environmental responsibilities, and carbon emissions, as well as effective communication of environmental policies and concerns [14,35,36].

Regarding the assessment of green performance, certain practices can be applied, such as those listed in Table 4:

Table 4. Green performance management practices.

Green Performance Management Practices	Author(s)
Development of a disciplinary system that promotes the adoption of environmental conduct	Bombiak and Marciniuk-Kluska [34]
Preparation of annual surveys measuring the impact of GHRM practices	Mamatha and Bharmappa [55]
Providing regular feedback to workers on their progress in achieving environmental objectives	Bangwal and Tiwari [56]
Development of positive reinforcement of environmental management (positive feedback)	Bangwal and Tiwari [56]
Development of negative reinforcement of environmental management (criticisms, warnings, and suspensions for failures)	Bangwal and Tiwari [56]
Penalty for non-compliance with environmental management goals	Bombiak and Marciniuk-Kluska, Renwick et al. [21,34]
Inclusion of a topic on environmental skills and know-how in the feedback interview	Opatha [57]
Assessment of the environmental performance of all workers	Renwick et al. [14]

Green Compensation and Benefits

According to Forman and Jorgensen [58], if aligned with the environmental strategy, the remuneration and benefits system promotes more significant commitment and a spirit of pro-environmental initiative on the part of workers and should, therefore, be encouraged. This system must include monetary and non-monetary benefits [59] to increase the effectiveness of motivating workers [14,38,60]. Several authors identify green compensation and benefits practices in their studies. Some examples are given in Table 5:

Table 5. Green compensation and benefits practices.

Green Compensation and Benefits Practices	Author(s)
Monetary:	
Using monetary-based environmental benefits (bonuses, cash, and prizes, such as credit cards to spend on green products)	Renwick et al., Bangwal and Tiwari [14,56]
Non-Monetary:	
Personalized offers to reward the achievement of ecological skills (e.g., a free day per quarter for the department that uses less paper)	Bombiak and Marciniuk-Kluska, Gómez et al. [34,61]
Offer of company promotional gifts aligned with the green culture campaign (e.g., lunch boxes, cups)	Gómez et al. [61]
Use of cash benefits environmental management on a non-monetary basis (special leaves, sabbaticals, gifts)	Renwick et al., Likhitkar and Verma [14,59]
Development of family promotion activities	Gómez et al. [61]
Use of environmental management benefits based on recognition (awards, advertising, external positions, regular praise, annual dinners with benefits for behavior most exemplary in this field, diplomas of merit)	Renwick et al. [14]
Benefits for creativity and active participation in green initiatives (career promotions, grants for environmental projects, environmental competitions)	Bombiak and Marciniuk-Kluska, Ari et al. [34,62]
Incentives for the use of bicycles as a means of transport (rented by the company) or use of more ecological (less polluting) vehicles	Saeed et al. [38]

Green Organizational Culture

The fifth and final area of GHRM intervention highlighted in this study is green organizational culture. Some authors, such as Renwick et al. [14], suggest the involvement and empowerment of workers as vital for a successful implementation of GHRM that will promote positive results for the organizations' environmental objectives. The involvement of workers in the environmental strategy must be promoted across everyone and not just to managers and intermediate positions. The empowerment of workers on these topics generates a desire for active participation in the company's environmental sustainability actions. In the specific case of this study, we converged the concepts of these authors—involvement and empowerment—designating this fifth dimension of green organizational culture. Understanding organizational culture as "a complex set of values, beliefs, assumptions, and symbols that define the way a company manages its business" [63] (p. 657), we believe this is the best definition of what this fifth dimension comprises in GHRM.

Tang et al. [35], aligned with the vision of Renwick et al. [14], advocate for an integrated approach to worker involvement that reinforces the designation adopted for this study. This approach involves five factors, namely (i) the green vision (values and symbols that support the environmental strategy); (ii) the green learning climate (corporate environment with a green conscience in which workers are concerned with good performance at the individual and group level); (iii) communication channels (formal or informal, which guarantee learning and green behaviors); (iv) green practices (pro-environment initiatives such as involving workers in working groups); and (v) encouragement of green participation (opportunities created for workers can actively participate in solving problems that promote common involvement, motivation, and environmental awareness). In this integrated approach, the organization's and individuals' values must be congruent since

workers are more concordant to demonstrate green behavior in the organization [46,64]. Likewise, the organization must provide a comfortable learning context where workers can improve their green behaviors and awareness. The environmental concern and clear communication demonstrating evidence of the organization's green values and environmental ethical commitments [46] are increasingly important for all stakeholders [65]. Likewise, the organization must provide a comfortable learning context where workers can improve their green behaviors and awareness. Finally, opportunities for active participation by workers are an effective way of motivating them to get involved in environmental management. Studies indicate that "an organizational culture that supports environmental management encourages employees to make suggestions and to engage in activities that improve the environment" [14] (p. 7). When workers have opportunities to participate, they demonstrate a greater willingness to prevent pollution and identify environmental opportunities [35,66]. Furthermore, it is important to recognize the importance of workers' tacit knowledge, which can benefit the company's environmental goals, since "workers have knowledge and skills that managers do not have" [67] (p. 1779). Some practices identified in the literature that fit into green organizational culture are listed- in Table 6:

Table 6. Green organizational culture practices.

Green Organizational Culture Practices	Author(s)
Use the knowledge of workers to improve the environmental performance of the company	Siyambalapitiya et al. [68]
Motivate workers to be green consumers outside organizations through pro-environment labor relations. Examples: encourage recycling at home; buy recycled products; give preference to public transport	Saifulina et al., Jackson et al. [9,19]
Promote green spaces in the company. Example: eco-design	Likhitkar and Verma [59]
Enable workers to take waste from home to work, inculcating the practice of waste separation and recycling in the home–work–home relationship	Renwick et al. [21]
Create environmental goals for the company and use communication channels to involve workers in this mission	Bombiak and Marciniuk-Kluska [34]
Adopt and monitor environmental commitments with suppliers	Gómez et al. [61]
Define the annual budget for the implementation of environmental initiatives by HRM	Bombiak and Marciniuk-Kluska [34]
Provide advisory services and support for solving ecological problems	Bombiak and Marciniuk-Kluska [34]
Prepare sustainability reports annually	Bombiak and Marciniuk-Kluska [34]
Recognize the involvement of workers in planning and green management activities	Ahmad and Nisar [36]
Encourage relations between employees to produce solutions to environmental issues. Examples: working groups and the elaboration of newsletters	Tang et al., Renwick et al., Daily and Huang [21,35,69]
Provide incentives for workers to submit green initiatives/promote team activities (e.g., environmental project competition)	Bombiak and Marciniuk-Kluska, Likhitkar and Verma [34,59]

1.1.3. Transversal Environmental Sustainability Practices in the Literature

For this study, it was considered relevant to conduct a survey of green practices that cut across various corporate dimensions, as these indirectly or directly touch the universe of HRM [70]. The performance of environmental management (EM) depends on the human resources that operationalize the strategy on a day-to-day basis [17], so it is vital that HRM maximizes employee motivation and engagement and ensures compliance with the corporate strategy. The examples listed in Table 7 aim to demonstrate the omnipresence of the concept of HRM in companies' environmental sustainability practices, from home office and car-pooling policies to the choice of gifts offered to employees and actions or disclaimers regarding good environmental practices.

Table 7. Transversal environmental sustainability practices.

Category	Transversal Green Practices in the Organization	Author(s)
Digital	Preference for home office or hybrid/flexible work;	Mamatha and Bharmappa, Amutha [55,70]
	Preference for teleconferences, interviews, and virtual meetings (versus face-to-face meetings that require travel);	
	Preference for digital manuals;	
	Online training/e-learning.	
Mobility	Company public transport, fleet of electric cars, bicycles;	Mamatha and Bharmappa, Amutha, Murari and Bhandari [55,70,71]
	Subsidizing passes for use of public transport;	
	Car-pooling policies (organize car-sharing framework);	
	Preference for the use of stairs instead of elevators.	
Products and waste	Total recycling of waste;	Mamatha and Bharmappa, Amutha, Murari and Bhandari [55,70,71]
	Partnership with organizations that treat waste and give it new uses;	
	Offer of ecological gifts (e.g., reusable shopping bags);	
	Encourage workers to bring plates and mugs to avoid disposable ones;	
	Preference for organic products (coffee or tea) and fair trade;	
	Preference for recycled paper and recycled toners;	
	Preference for providing filtered water instead of bottles;	
	Avoid using polluting products (e.g., cleaning).	
Infrastructures	Energy-efficient infrastructures (low-consumption lamps, timers on switches, photovoltaic panels);	Mamatha and Bharmappa, Amutha, Murari and Bhandari, Opatha and Arulrajah [20,55,70,71]
	Preference for office materials and furniture made from recycled materials;	
	Provide parking for bicycles/electric cars;	
	Green infrastructures using plants;	
	Large spaces with natural light to reduce electricity consumption (connect the smallest number of lamps).	
Performance	Elimination of workers' identification cards;	Mamatha and Bharmappa, Amutha, Murari and Bhandari, Opatha and Arulrajah [20,55,70,71]
	Reducing the number of prints on paper and avoiding color printing (green printing);	
	Preference for electronically filling out documents and digital files;	
	Conducting regular energy audits;	
	Consumption of natural water instead of refrigerated water (reduce electricity costs);	
	Avoid leaks in drainage systems for efficient use of water;	
	Shut down the computer when not used (instead of hibernating).	
Production	Green production (care in the use of water and the drainage system; use of low-harm chemicals);	Mamatha and Bharmappa, Likhitkar and Verma, Amutha, Murari and Bhandari [55,59,70,71]
	Use of alternative energies (solar, wind);	
Corporate events	Encourage plantations/vegetable gardens on company premises and workers' homes.	Mamatha and Bharmappa, Amutha, Murari and Bhandari [55,70,71]
	Develop environmental corporate activities involving all stakeholders (improves green identity and brand image);	
	Planting trees on workers' birthdays or annually (promotes green spaces and worker recognition).	

1.1.4. Benefits, Constraints and Challenges of GHRM

The adoption of Green Human Resource Management has several benefits for organizations. However, some constraints to its implementation and future challenges should be addressed. In this context, it is important to study and control some variables so that the environmental and human objectives of the organization are successfully achieved.

Several authors have studied and identified the benefits, constraints, and challenges of Green Human Resource Management.

Table 8 compiles this discussion, accounting for the respective impact at three levels: (i) macro level (society), (ii) meso level (organization), and (iii) micro level (worker).

Table 8. Benefits, constraints and challenges of GHRM.

	Macro (Society)	Meso (Organization)	Micro (Worker)	Author(s)
Benefits		Promotes a competitive advantage through economics and environmental sustainability		Renwick et al., Jabbour and de Sousa Jabbour, González-Benito and González-Benito [14,24,72]
		Allows the organization to analyze its environmental impact and solutions for improvement		Farzana [37]
		Promotes a healthy working environment (green spaces, less paper consumption)		Opatha and Arulrajah, Farzana [20,37]
	Preserve the environment and its sustainability			Mehta and Chugan, Farzana [37,51]
			Increases the motivation and confidence of workers by allowing them to conduct environmentally friendly practices	Likhitkar and Verma, Farzana [37,59]
			Improves the relationship between management/bosses and workers	Likhitkar and Verma [59]
		Improves organizational reputation	Increases the retention rate of customers and workers	Likhitkar and Verma [59] Muisyo et al. [73]
			Increases employee loyalty and well-being	Likhitkar and Verma [59]
		Allows the organization to improve its performance		Deshwal, Likhitkar and Verma [43,59]
		Reduces the company's overall costs		Deshwal, Opatha and Arulrajah [20,43]
	The balance between financial performance and environmental protection			Daily and Huang, O'Donohue and Torugsa [69,74]
	Emergence of new, more sustainable business opportunities			Santos et al. [75]
Constraints		The non-green environmental culture of the organization	Factors inherent to the worker (personality, values, lifestyle)	Labella-Fernández and Martínez-del-Río, Vahdati and Vahdati [76,77]
		Limited digital capacity of the organization (at the technological level—equipment)	Pressure on time management and efficiency of functions	Labella-Fernández and Martínez-del-Río, Vahdati and Vahdati [76,77]
		Fragile internal communication channels	Knowledge of the worker (qualifications, knowledge, digital literacy)	Labella-Fernández and Martínez-del-Río, Vahdati and Vahdati [76,77]
		High investment and low return (initial phase)	Different motivations for the environment among workers	Mehta and Mehta [4] Kodua et al. [78]
		Lack of environmental guidance from the top levels of the organization		Tanova and Bayighomog [79]
	Lack of adaptation of some sectors of activity			Amrutha and Geetha [27]

Table 8. *Cont.*

	Macro (Society)	Meso (Organization)	Micro (Worker)	Author(s)
Challenges		Implement GHRM planning across the entire organization		Farzana [37]
		Lack of green infrastructures and technologies		Farzana [37]
	Need for continuous process development, marked by global trends and regulatory instruments			Agrawala et al. [80]
		Difficulty in transforming a traditional HRM attitude to GHRM	Difficulty in measuring the effectiveness of GHRM practices on workers' behavior	Mehta and Mehta [4]
		Implementing a green culture is a time-consuming and complex process		Mehta and Mehta [4]
			A lack of knowledge in environmental matters can generate limitations and a lack of cooperation between the organization's specialists	Fayyazi et al. [81]

Looking closely at the facts in Table 8, one of the most significant constraints that could affect the implementation of a GHRM is the intrinsic resistance of the organization's human capital. Although the benefits associated with GHRM are many, particularly in terms of overall costs, motivation, and employee retention, which results in an important competitive advantage, it is impossible to ignore the challenges inherent in implementing management that presupposes deep and transversal change processes. The path to an effective GHRM will involve a solid initial investment, complex multidimensional planning, and a system of continuous improvement, bearing in mind the changes that are emerging at a global level.

2. Methods

Based on a qualitative-intensive methodological design [82], the research question that guided this study was the following: *Which are the Green Human Resource Management practices implemented in companies operating in Portugal?*

The main research goals were as follows:

1. Identify Green Human Resource Management practices in companies operating in Portugal that have environmental management system certification, specifically the ISO 14001 standard.
2. Identify transversal environmental sustainability practices in companies in Portugal with the ISO 14001 standard.
3. Identify benefits, constraints, and challenges for companies associated with GHRM from the perspective of their Human Resource Management professionals and those responsible for environmental sustainability.

2.1. Procedures and Sample

Based on an exploratory approach, the inclusion criterion was defined as companies in Portugal certified with the ISO 14001 standard since this certification constitutes a guarantee of concern and application of environmental measures by organizations [9].

Considering the sampling strategy, we used a convenience sample. Companies were selected to participate in this study, considering the following criteria, many of them resulting from a previous research work: (i) sector of activity, in order to obtain a comprehensive plot that encompassed several areas of activity; (ii) associativity that demonstrates awareness for the environmental cause, namely associated companies from the Business Council for Sustainable Development (BCSD) Portugal; (iii) recognition by the Science

Based Targets initiative (SBTi) and validation of the organization's goals; and (iv) awards and distinctions advertised on the official pages of companies or on news channels that, from the outset, identify and reinforce the assumption that these organizations implement Green Human Resource Management practices. Between the beginning of February and mid-May, 133 companies were contacted: 84 people via email and 49 via LinkedIn, of which 28 responded to the contact, and 15 freely agreed to participate in this research. The interview phase was concluded when theoretical saturation was reached.

A group of 15 individuals participated in the present study, with the following socio-professional characteristics: 10 female and 5 male; the average age of the participants was between 41 and 50 years, with the youngest participant being below 30 years old and the oldest being between 51 and 60 years old. Regarding literary qualifications, most of the participants had a qualification at the higher education level. In total, 1 participant had secondary education; 8 had a bachelor's degree, 5 had a master's degree, and 1 participant had a doctorate. The educational background of the participants was quite diverse, varying between human resources (8 participants), psychology (2 participants), engineering (2 participants), sociology (1 participant), environmental management (1 participant), and geology (1 participant).

The average seniority of these professionals in the respective organizations was 7 years. Concerning their current position, these professionals had diverse functions distributed by the departments of human resources (HR) and environmental management (GA).

Regarding the characterization of the organizations that the participants represented, we identified different profiles regarding their size, location, and sector of activity. Of the 15 organizations, only 3 were medium-sized companies with less than 250 workers. The remaining 12 companies had more than 250 workers; namely, 1 had between 250 and 499 workers, 4 had between 500 and 1000 workers, and 7 had more than 1000 workers. As for their location, the district where they had infrastructures certified with ISO 14001 was considered. Regarding the sector of activity, different enterprises were considered, thus guaranteeing the diversity required for this exploratory study (please check Table A1 in Appendix A).

2.2. Instruments and Analysis Procedures

In line with the goals proposed for this study, two central techniques for collecting data were used: (i) semi-directive interviews and (ii) document analysis. The latter was used in the final phase of the investigation to reinforce the information collected through the interviews. Choosing interviews as a data collection procedure facilitates a comprehensive understanding of the phenomenon under study, as it not only allows the identification of GHRM practices recognized by the interviewed professionals but also clarifies their view of the conditions, benefits, and challenges of GHRM. This exploratory method was used by researchers such as Paillé et al. [83] and Yu et al. [84], who interviewed managers to corroborate the relevance of the GHRM measurement instrument they developed, enabling the exclusion of items or practices that did not exist or were not relevant in the context of the organizations studied. In this case, the aim is to guarantee the rigor of the exploratory research, using more than one information collection technique to ensure that the GHRM practices identified are accurate and current. Indeed, concerning documentary analysis, since GHRM is a recent and potentially unknown topic, there was a need to explore official data available from participating companies (institutional websites of companies, sustainability reports) in order to include other GHRM practices not identified by the participants during the interviews, mainly due to lack of knowledge. Therefore, their complementarity justifies the choice of these two main techniques—interview and document analysis.

On the one hand, interviews allow us to clarify how the GHRM practices indicated are planned and carried out, using the vision of those who are the drivers of these practices and strategy among workers—human resource professionals together with those responsible for the environmental sustainability strategy of companies certified with the ISO 14001 standard in Portugal. On the other hand, more content is gathered through the documen-

tary analysis of official and credible sources, and information previously provided in the interviews is validated.

After confirming the participants for the collaboration in this study, interviews were scheduled, according to the availability of the participants, via Zoom or Teams. The choice of the online format, to the detriment of face-to-face interviews, was guided by the agreement with the assumptions of reducing the impact of the carbon footprint valued by the theme of environmental sustainability addressed in this study.

The semi-directive interviews were conducted using a script organized into a total of seven blocks, with three main parts: the first part related to the identification of the interviewee and the company; the second part related to the identification of HRM practices subdivided into the five areas under study, as well as the survey of general environmental sustainability practices; and, finally, a third part that sought to identify the benefits, constraints and future challenges of HRM implementation as perceived by the interviewee. At the end of the interview, there was room for final comments and suggestions.

Specifically, the first section sought to characterize the interviewee ("What is your role in the company?") and the organization ("How many employees does the organization currently have in Portugal?"). Then, in a second block, we focused on pertinent questions to ensure good contextualization and interconnection of the topics, addressing the concept of GHRM ("Are you familiar with the concept of GHRM?"). It should be noted that, in order to ensure an effective survey of GHRM practices implemented by organizations, and in order to enlighten the interviewee about the concept, clarification was made about what GHRM is in the context of the current research and in light of the literature. This clarification was only given in cases of unfamiliarity with the subject and only after a question about familiarity with GHRM had been asked.

The third block brings together questions about GHRM practices ("Focusing on specific HR areas, I would now ask you to tell me about the practices implemented, using concrete examples whenever possible") organized into the five areas of study, namely green recruitment and selection ("How are job vacancies communicated and how are candidates selected?"); green training and development ("Does environmental management training cover all the company's roles and departments?"); green performance management and evaluation ("Is there a performance appraisal designed to cover environmental metrics?"); green remuneration and rewards ("What kind of rewards and benefits are associated with green practices by employees?"); and green organizational culture ("Does the company have a green organizational culture, based on an ecological vision and values?").

The company's general practices with a focus on environmental sustainability were addressed in the fourth block ("What other green initiatives do you implement across the organization?") in order to identify other cross-organizational green practices that demonstrate the company's green vision—as perceived by the interviewee—which, in exploratory terms, could even be related to one of the five areas mentioned above.

The fifth block focuses on the benefits identified by the interviewee, at the employee, company, and global levels ("If you could highlight the best tangible benefit for your organisation of implementing GHRM, what would it be?"), followed by the sixth and seventh blocks that focus on the constraints and future challenges, respectively, according to the interviewee's perspective and also distinguished at an individual, corporate, and societal level.

The interviews were conducted between the beginning of February and the middle of May 2023. All interviews were recorded in audio format, and their transcripts constituted the corpus of the work, which was then subjected to content analysis. The shortest interview lasted 01h04, and the longest lasted 2h46, with an average duration of 01h33. These interviews were quite heterogeneous in terms of their duration due to the freedom of speech that the interviewer intended to give the interviewee to obtain the greatest possible depth on the subject.

After conducting interviews and being attentive to the aim of this study, they were selectively transcribed since transcription is a procedure that involves "reducing, inter-

preting and representing oral conversations so that the written text is understandable and has meaning" [85] (p. 127). In this way, the focus on the accuracy of the information content was guaranteed [86] as well as the fulfillment of the deadlines defined for this research. It should be noted, however, that all the necessary steps were taken for a secure, accurate, and reliable transcription, using methods that involved (i) copying the recordings on more than one device with restricted access to the researcher, (ii) free NCH® Express Scribe software (13.06 version) to support the task through the possibility of repetition and audio slowdown, and (iii) support of notes taken at the time of the interview. Also, in this process, an initial hearing of the recording in full was conducted to identify the particularities of each interview, as well as a subsequent review to compare the transcribed text with the recording.

Subsequently, exploratory documentary research was conducted on the participating companies to support and solidify the information collected in the interviews with the company's external communications. Based on this study's reliability and validity criteria and considering its objectives, we conducted document analysis through different information channels, such as (1) the organizations' official websites; (2) official company pages on social networks, namely LinkedIn and Facebook; and (3) the Google search engine. The collection of information from the organization's official website was in depth, analyzing all available menus and published texts, namely sustainability reports, newsletters, and other official documents. Regarding official pages on social media, a search for publications was carried out between May 2022 and May 2023 on the topic of "environmental sustainability". Finally, using Google search, relevant news on environmental issues was collected and placed in the search, along with the name of each organization, and keywords such as "sustainability", "environmental", "carbon footprint", "workers", and "collaborators".

Regarding the analysis procedure, the data from the interviews were categorized and coded to reduce the complexity and to enhance understanding and interpretation. Therefore, transcripts were analyzed using thematic analysis [87], highlighting and coding the relevant extracts. Themes and subthemes were refined, revised, and organized into categories according to the relationship between the codes, coherently [88]. To ensure the reliability and validity of the data obtained, categories and citations were evaluated separately by two researchers (analysts' triangulation) [89].

3. Results

In this section, we present our analyses of the responses obtained from the participants in this study. Data presentation is organized similarly to the presentation in the literature review, that is, focusing on the five main areas of GHRM (recruitment, training, performance management, benefits, and organizational culture), as well as on transversal environmental sustainability practices and, finally, on the benefits, constraints, and challenges associated with GHRM in the micro, meso, and macro levels.

3.1. GHRM Practices in Portugal

3.1.1. Green Recruitment and Selection

It can be seen from the empirical analysis that some practices recommended in the literature are already being applied in companies in Portugal; namely, the recruitment and selection process adopted is increasingly digital. For example, (i) job advertisements are published on online platforms and (ii) the recruitment process is conducted through an online platform (including submission of documents).

However, some practices prevail and, according to the literature, limit multidimensional environmental strategy implementation. The maintenance of paper documentation is due to legal impositions (e.g., employment contracts), as referred to by I4 (Interviewee 4) (*"I would be a fan of paper-free, but legal constraints may not allow it, and therefore, contracts are printed on paper" (Interviewee 4, Human Resources Director, Company 4))*, but also to Portuguese workers' lack of digital literacy (e.g., paper application forms).

In terms of job advertisements, it is not common practice to share a company's environmental values, except for vacancies intended for environmental positions requiring specific skills for the function performed. Plus, in the section process, there is no preference between candidates regarding their environmental values and motivations, as I3 states, "*We do not discriminate against any candidate because they are not green*" (Interviewee 3, Head of Sustainability, Company 3).

3.1.2. Green Training and Development

In green training and development, companies make a notable effort to bring this environmental theme to their workers. In two specific cases, the creation of sustainability academies is confirmed. Considering the key practices of the literature, we perceive that environmental training is cross-sectional and mandatory, and mostly takes place in onboarding; "*All workers who enter the company must undergo training in the environment. One of the sections of onboarding is the environmental area, all without exception.*" as pointed out by I10 (Interviewee 10, Head of Environment, Health and Safety, Company 10).

Also, the contents of environmental training are varied, covering topics such as biodiversity, management of water, paper and electricity consumption, and waste separation. The effectiveness of the training is applied by a small number of the companies interviewed, as stated by I11: "*In all training, there is a final evaluation and a survey with improvement suggestions*" (Interviewee 11, HR Business Partner, Company 11).

Despite the increasing emphasis on the theme among workers, there is a superficiality in the approach that implies reflection. Training on environmental issues fits into a global, general, and primarily welcoming phase for new workers, and there is no real assessment of the individual training needs of each worker. This, combined with the lack of performance analysis of post-training, can negatively influence the effectiveness of the training. These aspects are often neglected due to a lack of time and resources in the HR department, as pointed out by I12: "*We do not measure the impact levels of training at this level, due to scarcity of resources and time in the HR Department*" (Interviewee 12, Human Resource Specialist, Company 12).

3.1.3. Green Performance Management

The empirical analysis shows that although performance evaluation is an underdeveloped area of GHRM, there is a concern for correct, conscious, and shared environmental performance, through a willingness to involve and make managers responsible for evaluating environmental performance and achieving a general mentality of co-responsibility through informal feedback and participation of workers. In fact, the importance of the role of the managers is frequently mentioned, and it is understood, as I10 says, that "*This should be the main point of management and against which they should also be evaluated*" (Interviewee 10, Head of Environment, Health and Safety, Company 10).

However, the reality of companies in Portugal shows that they still need to prepare for a planned and effective green performance assessment. Only two participating companies mention evaluating workers on their ecological footprint without detailing the metrics for this purpose. Thus, it is observed that environmental performance assessment exists only in technical functions associated with the environmental area so, in general, the performance evaluation system with an environmental component does not exist. This shows that it is extremely important for the job description to include environmental aspects on which workers will subsequently be assessed, regardless of whether their job is linked to this area. In this regard, it should also be noted that public companies are limited to the legal guidelines to which they are obliged, as I8 mentioned "*We are obliged to have the SIADAP (Integrated performance management and evaluation system in Portuguese public administration.), and if the "environment" is not there explicitly, we cannot have "environment" in the competencies*" (Interviewee 8, Head of Human Resources Division, Company 8).

3.1.4. Green Compensation and Benefits

Considering the data collected, this is an area of HRM that is little explored and valued in the participating companies. Over half of those interviewed did not mention this type of award or incentive as a frequent practice in their company, as I13 says that "*We do not have much of a benefits or bonus policy, neither in the environmental area nor in any other area*" (Interviewee 13, Continuous Improvement Manager, Company 13). However, few examples of monetary awards are identified, despite their restriction to the top levels within the achievement of the company's global goal, as I9 alerts to the fact that "*only the management committee, and some second-level departments, have annual objectives and cover the environmental part insofar as it covers the company's sustainability objectives*" (Interviewee 9, Human Resources Director, Company 9). Also, green benefits are only mentioned by companies with economic activity compatible with offering discounts on services or purchasing green equipment (e.g., energy, mobility solutions).

Regarding non-monetary awards, they are not widespread either, but some examples can be identified like annual meetings of workers where the most sustainable teams are rewarded, as indicated by I11: "*We have at least one annual meeting where we do (. . .) a general assessment, namely how much paper we save. . . and we reward the winning teams. We implement this part of praising a lot*" (Interviewee 11, HR Business Partner, Company 11). Plus, some groups or internal competitions are mentioned, in which the most ecological worker is distinguished (e.g., eco-driving).

3.1.5. Green Organizational Culture

Green organizational culture is the most complex and wide-ranged area of HRM because it is the day-to-day actions of workers and the opportunities granted that will build green awareness, values, and commitment. This study demonstrated that there is a green culture across participants, although with distinct levels of maturity. The clarity for workers regarding the green vision of their company is strongly linked to the business sector and internal communication on environmental issues, which is stronger in those companies that perform in environmental business and have good and diverse channels of communication (e.g., corporate radio, digital channels), as stated by I6, who has "*a dynamic communication channel with content on the topic, challenges, which are normally more organized by marketing in collaboration with human resources*" (Interviewee 6, Development Manager Human Resources, Company 6). Also, it is noted that there is freedom of initiative for workers in the company's environmental strategy, and employee involvement stands out in those companies who assume regular and strong environmental communication, as I9 mentions, saying "*The fact that we have this constant pressure to bring sustainability to the business ends up rubbing off on our people*" (Interviewee 9, Human Resources Director, Company 9).

However, there are key aspects for green organizational culture to be disseminated among workers that cannot be overlooked by companies; namely, the workers' involvement is related to the real opportunities for participation that the company provides (e.g., activities should happen during labor time, as affirms I13, showing that they "*did not have the participation we wanted because the company also did not allocate (. . .) working hours so that people could do corporate volunteering*" (Interviewee 13, Continuous Improvement Manager, Company 13)). Also, companies must look at their reality and try to adapt in an agile and sustainable way. For example, I7 said they "*have a newsletter, but it only reaches those who have email, which is 30%*" (Interviewee 7, Human Resources Director, Company 7). As the lack of digital literacy may negatively impact green organizational culture, workers' freedom of initiative and participation must also be real.

3.2. Transversal Environmental Sustainability Practices in Portugal

Focusing on additional transversal environmental sustainability practices implemented by the companies' participants in this study, we present the results below in Table 9, distinguishing different categories, aligned with the literature review.

Table 9. Transversal environmental sustainability practices identified in this study.

	Practices Identified
Digital	Preference for hybrid work E-learning training
Mobility	Fleet renewal for electrics Promotion of car-sharing Encouraging the use of public transport and electric bicycles
Products and waste	System of waste separation and management Preference for the use of recycled articles and organic products Welcome kit with sustainable items (e.g., bottles, mugs) Use of filtered water systems Promotion of a fair trade and circular economy
Infrastructures	Eco-design and creation of outdoor green spaces More sustainable facilities with good energy efficiency Acquisition of recycled furniture Car parks with electric charging stations
Performance	Actions in terms of saving water and equipment energy Acquisition of more sustainable systems Elimination of access cards
Production	Use of renewable solutions to support energy costs (e.g., photovoltaic panels)
Corporate events	Cleaning beaches or green spaces Tree planting Actions to raise awareness of biodiversity and nature within the workers or the community Investment in green gamification

This study showed that there are several practices that have a positive impact on companies' environmental strategies that are aligned with the GHRM. With regard to the use of digital technology, it is clear that hybrid work is the most used, although it is limited to companies that cannot apply it because of their activity. There has also been an increase in training through e-learning models; however, face-to-face and "on the job" training are still frequent, often associated with the industry but also with the employees' lack of digital literacy, as I7 states that "*It is all face-to-face because with these employees, doing online training is almost impossible*" (Interviewee 7, Human Resources Director, Company 7). Electric mobility has been widely embraced by companies, with a growing trend towards the total or partial acquisition of an electric fleet. In addition, the use of public transport and electric bicycles has been promoted, and there are partnerships with suppliers for employees to purchase them at more advantageous prices. I5 even has "*(. . .) a set of bus lines dedicated to employees*" (Interviewee 5, HR Business Partner, Company 5). It should also be noted that car-sharing is a frequent practice among workers, either managed by themselves or with involvement of the company; I10 states that "*We have a car-sharing platform*" (Interviewee 10, Head of Environment, Health and Safety, Company 10). Regarding the goods used in the companies, there is a growing concern with the use of sustainable products, not only in the welcome kit where the items mentioned include water bottles and reusable cups or lunch boxes like I9 (Interviewee 9, Human Resources Director, Company 9) shared, but also in daily business through recycled items such as toners and paper. In addition, there is a preference for fair trade and the circular economy, as stated by I13 (Interviewee 13, Continuous Improvement Manager, Company 13) ("*There is also the concern of purchasing from local suppliers.*") and I4 (Interviewee 4, Human Resources Director, Company 4) ("*We have a project to recover pallets*"). In the area of nutrition, there are also positive initiatives, not only with regard to the selection of products cooked in the cafeterias but also in the management of waste, as indicated by I5 (Interviewee 5, HR Business Partner, Company 5), who will be cooking healthier and more organic food in the company's new facilities and when there is space for the "*separation of waste and organic waste that can be used for composting*". Filtered water machines were also mentioned, particularly by I9 (Interviewee 9, Human Resources Director,

Company 9), whose company offers a recycled bottle to all employees. Sustainability starts at home, and several practices are identified that demonstrate companies' investment in becoming greener, such as moving to more sustainable buildings or campuses with green spaces, or redesigning facilities to be more connected to the environment, with small gardens and using eco-design as an ally. An example of this is I13's statement that "*our spaces breathe green, starting with the wallpaper that looks like a forest*" (Interviewee 13, Continuous Improvement Manager, Company 13). Also noteworthy is the creativity of some companies who, with the participation of their own employees, have built sustainable spaces made from recycled materials, such as I10's company, where "*We replaced the light fixtures and created a terrace made of old pallets*." (Interviewee 10, Head of Environment, Health and Safety, Company 10). Ecological performance is also valued and involves raising awareness among human resources to act with compliance and technological strategies that help make performance more effective, such as eliminating the physical employee card to access the facilities, using a smartphone instead, or automatically turning off the lights in the facilities at the end of the day. In the case of I6, printers have been reduced to a minimum to avoid printing—"*We no longer have printers per service so as not to encourage printing*." (Interviewee 6, Development Manager Human Resources, Company 6). In companies related to the environmental sector, water saving was highlighted by tanks, such as I7's company, where "*The washing of the truck is essentially done with rainwater*" (Interviewee 7, Human Resources Director, Company 7).

Regarding production, the choice of alternative energies is common, such as photovoltaic panels, to make it more sustainable. An example of this is highlighted by I3 (Interviewee 3, Head of Sustainability, Company 3) and I13 (Interviewee 13, Continuous Improvement Manager, Company 13), who stated that "*The transition to 100% renewable electricity in our offices is something that is already happening*" and that "*We have created a park for vehicles with electric charging, powered entirely by photovoltaic panels.*", respectively. Finally, with regard to corporate events, it seems that the activities related to the environment promoted by various departments, including human resources, are fairly consensual among the participating companies, demonstrating their commitment to raising awareness of the issue among employees and the community. The most common are planting trees and cleaning beaches or green spaces, "*because they are usually supported by local authorities*", says I5 (Interviewee 5, HR Business Partner, Company 5). However, it is possible to identify activities to raise awareness of biodiversity and nature among workers or the community through art, as referred to by I6 (Interviewee 6, Human Resources Development Manager, Company 6) ("*We made a mural about biodiversity and recycling*"), or through direct contact with species such as bees, as was the example of I14 (Interviewee 14, Head of People and Culture, Company 14). Also allied with new technologies, investment in green gamification is beginning to appear.

3.3. Benefits, Constraints, and Challenges of GHRM in Portugal

The empirical analysis demonstrated several benefits associated with GHRM that affect workers, companies, and civil society. However, participants raised significant constraints and challenges that GHRM in Portugal may face.

3.3.1. Benefits of GHRM in Portugal

Concerning the benefits associated with GHRM, it was possible to identify that most of the interviewees believed that GHRM helps the preservation of the environment and its sustainability. Regarding the impact on the companies, it is believed that GHRM allows the organization to improve its performance and reputation. Also, it reduces the company's overall costs and "*In the long term, it will pay off much more, such as the platform to digitize the HR process*" (Interviewee 11, HR Business Partner, Company 11). Finally, it promotes a competitive advantage as "*It brings a strong brand and also the financial component.*", affirms I6 (Interviewee 6, Human Resources Development Manager, Company 6).

GHRM also has a positive impact at a micro level, helping increase customer and worker retention, "*especially from new generations*", believes I2 (Interviewee 2, L&D Coordinator, Company 2). The employees' motivation is also mentioned, and I15 (Interviewee 15,

Human Resources Director, Company 15) believes that this different approach "*will make employees (. . .) much more soulfully connected to the company.*" Ultimately, "*the company's green awareness promotes employee well-being*", as referred to by I11 (Interviewee 11, HR Business Partner, Company 11).

3.3.2. Constraints of GHRM in Portugal

Regarding the macro constraints associated with GHRM, participants mentioned the lack of adaptation of some sectors of activity like transport. I7 states that "*In the case of trucks, the problem is when and where to load the trucks. I do not know how this will be possible.*" (Interviewee 7, Human Resources Director, Company 7). Legal obligations, such as notarized signatures in many documents, or the lack of state financial support, are also limits, as affirms I3, because their application "*does not apply to companies in terms of electric chargers.*" (Interviewee 3, Head of Sustainability, Company 3). In this matter, I15 (Interviewee 15, Human Resources Director, Company 15) believes that "*Governments also have an important role in this, which is to create incentives for this to happen.*"

Finally, the lack of specialized suppliers for electric bicycle fleets is a constraint, as says I2, because "*sometimes the companies that provide these services are not expecting what we ask for*" (Interviewee 2, L&D Coordinator, Company 2). Likewise, the lack of public transport serving the entire region is also mentioned, as it is difficult to attract people, especially the new generation.

Regarding the constraints at a meso level, i.e., in the company's perspective, it is perceived that GHRM implies a high investment, as affirms I13: "*These measures are very conditioned (. . .) because they involve many costs*" (Interviewee 13, Continuous Improvement Manager, Company 13). Also, it will be difficult to put it into action if there is no environmental guidance from top levels, as happens in I15's company, where "*The managers' vision is not very green*" (Interviewee 15, Human Resources Director, Company 15). Plus, in a department that is usually short of people, the lack of human resources to manage this strategy is, certainly, a constraint, as I8 notes: "*My biggest obstacle is having enough people in HR to do what we dream of as a team*" (Interviewee 8, Head of Human Resources Division, Company 8).

In addition, at a micro level, a perceived constraint was the fact that there are different motivations towards environment among workers, and "*some people say that 'this is nothing', therefore, there is little credibility and true perception of this theme.*", as shared by I10 (Interviewee 10, Head of Environment, Health and Safety, Company 10). Plus, workers' level of education and digital literacy are heterogeneous, and there are some companies where most workers do not even have an email, for example.

3.3.3. Challenges of GHRM in Portugal

The future of GHRM presents some challenges that should be considered. At a macro level, there is a need for the continuous development of processes, influenced by global trends and regulatory instruments. Also, it is mentioned that the focus on sustainability is limited by the educational system. I13 (Interviewee 13, Continuous Improvement Manager, Company 13) argues that "*There is always legislation emerging that can directly affect our business, and it is always towards a more sustainable environmental path. This issue of sustainability is not considered in many educational programs (. . .), and therefore, people in the human resources field are often not sensitive to these issues*".

At a meso level, inside the companies, it is challenging to implement cross-organizational GHRM planning, and transforming traditional HRM attitudes to GHRM is difficult and time-consuming, as shared by I12 (Interviewee 12, Human Resources Specialist, Company 12): "*Changing habits is an extremely complex and time-consuming process*".

Finally, at a micro level, the issue of measurement must not be forgotten, as it is difficult to measure the effectiveness of GHRM practices on worker's behaviors, keeping in mind that the organization needs to be completely aligned, as I10 (Interviewee 10, Head of Environment, Health and Safety, Company 10) points out: "*I would say that it is difficult to measure. (. . .) It is very difficult to do because it requires all people to be involved here.*" Additionally, tested measuring tools

should be developed in this field: "*There is not much information about this. Companies develop inside doors*" (Interviewee 7, Human Resources Director, Company 7).

4. Discussion

The concept of GHRM is recent, and a generalized unawareness on the part of the participants was identified, associated in specific cases with a broader concept of Sustainable HRM, something that accompanies the development of the literature, which acts simultaneously on a broader and more specialized plane [30].

Regarding the primary areas of GHRM, a greater presence of the environmental aspect is identified in the training areas of green development and green organizational culture, which guarantees the freedom of participation of workers in an increasingly valued bottom-up orientation, as well as consistent internal communication on the subject.

Looking at the area of green recruitment and selection, we found that at the level of digitization of the system, there is a markedly positive trend since most companies adopt digital measures that allow processes to be sped up and, consequently, a guaranteed reduction in paper consumption [37]. It is important, however, to highlight the involuntary limitations that many companies face that run counter to the environmental strategy they would like to implement: legal constraints and lack of digital literacy of candidates, which determine a preference for paper.

There was no direct evidence of a preference for pro-environment candidates, excluding the sharing of the company's environmental strategy from job advertisements. This finding reveals that participating companies may be limiting the inclusion of candidates who act voluntarily based on environmental citizenship, which contributes to the organization's sustainability [39]. In addition, the omission of companies' green values in advertisements may, according to Saeed et al. [38], withdraw the candidacy of workers with these values because they are unaware of the way in which organizations act in this scope. The implementation of environmental criteria in the description of functions other than those directly associated with the environmental management of companies, as argued by Mehta and Mehta [4], was not identified in a generalized way.

Green training and development, as mentioned above, is the GHRM area at a more advanced stage, with a positive frequency of training actions, mainly in the onboarding phase, which covers all workers in a transversal way. This coverage is understood by several authors as crucial for the success of the results [48,49]. However, an important aspect is that this training does not assume a specialized direction, often considered a wider sustainability 'package'. The training evaluation is mentioned but not generalized by the companies studied. This action not only concerns post-training evaluation but also guarantees its effectiveness and improvement of the environmental performance of workers [14].

Regarding the area of green performance management, environmental criteria were undervalued from the outset, so it was possible to understand the need for adherence to establishing key environmental performance indicators in the functions in a transversal way. It has only been observed that there are environmental metrics in the functions associated with this area, something that reflects that environmental responsibility is not associated with all workers in a uniform way, assuming the absence of environmental criteria in the job description of all workers, as Mehta and Chugan [51] and Mwita [52] defend. The interviewees do not recognize the green performance management process as simple and objective. However, it is accepted by the majority that the involvement of bosses is a key part of the success of the environmental performance of workers. Despite this conjecture, it is found in this study that the bosses are not yet deeply committed, a fact that may suggest the need to integrate the evaluation of the performance of the teams into the evaluation of the bosses themselves, something already recognized by Ahmad and Nisar [36].

Green compensation and benefits and, specifically, a system of incentives and benefits for good environmental performance are not generally rooted in the participating companies. Despite this finding, there are monetary benefits in some cases, with a scope limited to executive levels and focused on achieving the company's objectives and not on individual performance. This fact

departs from the understanding of Forman and Jorgensen [58], who argue that the system should be applied to workers as it promotes an increased commitment to environmental practices. As far as non-monetary benefits are concerned, they have not been solidified.

Finally, this research demonstrates that, in green organizational culture, the clarity of the organizational green vision on the part of workers exists in companies that are invested in transferring the environmental strategy to the daily life of workers in an integrated approach, as defended by Renwick et al. [14]. Sharing the idea of Dumont et al. [46], this green culture is transmitted in the way organizations communicate, in the activities they conduct, and in the freedom and involvement they promote with them, and there must always be a congruence of green values. It is found that companies that implement GHRM assume a very pronounced level of clarity of green vision for their workers, especially when it comes to internal communication of green activities and the promotion of a green sustainable culture, both with positive impacts regarding person–organizational fit [90]. In the same way, in companies where consistent, diversified, bi-directional, and close internal communication is applied (often in the sense of informality), there is also a positive perception of the interviewees regarding the understanding of green culture on the part of workers. Given the results obtained, the involvement of workers is inherent in the conditions that the company provides, that is, in real opportunities for active participation in environmental initiatives.

Across all interviewees, GHRM is understood as something beneficial and relevant to companies' environmental strategies. According to the results, organizations' positive impact on the planet's environmental sustainability is assumed, made possible by the improvement of their performance and the responsibility that companies have towards their workers, today and in the future, and society. Furthermore, this globalized concern for the environment positively impacts organizational reputation, generating a competitive advantage and greater customer loyalty. This involvement with green issues also has an internal impact, with interviewees highlighting the increased motivation of workers and, consequently, the retention rate [59], which is extremely important if we consider the current challenges in recruitment and retention of talents.

In this study, however, it was possible to identify constraints that limit the implementation of GHRM in companies, particularly in terms of reduced state support and legal obligations [79] that still apply and that limit, for example, digitalization. Something identified by some interviewees is the fact that some sectors of activity have greater restrictions on what can be green practices [27], often related to dependence on fragile external offers, such as vehicle autonomy and limitations in the supply network for electric vehicles at the country level. Also highlighted is that the ability to respond to external impositions for a green strategy and the financial "lungs" of companies are different, with mention being made of the difficulty SMEs have in participating, on an equal basis, alongside large companies [74]. This high investment associated with GHRM, already identified by Mehta and Mehta [4], implies a green orientation and vision on the part of the top levels of companies that may often not occur. The lack of professionals in the HR area promoting these practices also has a negative impact. Many structural tasks overlap with GHRM initiatives. Also, a factor inhibiting the adoption of a GHRM raised by the participants is the different motivations and environmental literacy of workers, who may have more or less environmental sensitivity and knowledge [76,77].

It is clear from this study that there are several challenges to implementing GHRM, firstly due to the need for companies to be constantly updated on global trends or regulatory instruments that impact their activities. Organizations need elasticity to continue developing in a continuous improvement logic, as Agrawala et al. [80] argue. However, the future involves increasing environmental responsibility for companies, understood as a guarantee of the business's future. Likewise, the future must also involve a serious commitment on the part of academic entities to integrate these themes into the national education agenda, something also already signaled by some authors [3,52]. The transformation to a GHRM involves multidisciplinary and multidirectional internal mutations so that it is possible to convert the traditional HRM process into a solid GHRM.

5. Conclusions

5.1. Contributions of the Study

Considering the urgency of the theme of environmental sustainability in the current context in which we live and the still unexplored nature of Green Human Resource Management (GHRM) in Portugal, which was the object of study, this research aimed to contribute to the advancement of knowledge in this specific area of Human Resource Management, as well as make a call to action for organizations that want to initiate or deepen a sustainable path.

This study aims to have scientific and socioeconomic relevance. From a scientific point of view, it seeks to address a still underpopulated subject, initiating an exploratory path on GHRM in the Portuguese reality, considering analysis models and practices already identified in previous studies. The collected information allows for the enrichment of empirical analysis in this area and a mapping of the current reality of GHRM in Portugal, revealing some specificities of its operation, considering the Portuguese economic fabric. Indeed, it was possible to observe limitations of the public sector in implementing GHRM practices, as they are not provided for in the regulatory models on which they are based, and the difficulties of SMEs in keeping up with global trends that demand GHRM without compromising the sustainability of their business, due to unsatisfactory government support.

At the same time, this research has socioeconomic relevance in the sense that there is a great interest from parties in environmental issues, particularly civil society, generating mass pressure on the organizations that depend on it to implement a sustainable strategy. There is a perceived urgency for companies to apply a solid, transparent, and multifaceted system based on strong and rooted ecological pillars, in which GHRM must assume a guiding and facilitating conduct of action. This study emphasizes the importance of giving a prominent role to GHRM, which acts on and through the actors that constitute (or will constitute) the human capital of companies and that concretely conduct the processes that guarantee the effectiveness of the corporate environmental strategy [91,92]. In contradiction, reality still tends towards a more operational and environmental management focus, revealing gaps and a fragmented application of GHRM practices. This research aims to provide tools that provide an improvement exercise to organizations that already apply a GHRM, namely in adopting a holistic method, which promotes an immersive environmental experience for workers, fulfilling the essential green steps in each of the areas of HRM. Furthermore, the aim is to provide tools to organizations that intend to implement this type of management practice, suggesting the assessment of the GHRM policies outlined in this study and adapting them to their context.

It is concluded that the organizations of the future will have to imperatively include environmental sustainability in their strategy [93] and that GHRM will have significant growth in the coming years, which should go through a deeper integration, both in practice/intervention and academy/research in HR. It is important to couple these two worlds, deepening empirical knowledge and directing it to the needs of organizations while integrating into these entities the perceived learnings and the new talents that sprout, eager to positively impact the organizations that host them and the planet on which we live.

5.2. Limitations and Further Research Suggestions

This study includes some limitations, first, due to the inclusion criterion that limits the sample to companies holding ISO 14001. As such, broader research is suggested for the future, integrating companies that do not hold environmental certifications. Time constraints on the research, limiting it to less than one year, led to an exploratory study focusing on a diversified but limited sample. This limitation prevented a more comprehensive study that could bring more relevant empirical material to the literature with consistent or different results.

Indeed, despite the heterogeneity of the sample obtained in this study, comparative longitudinal research would be interesting to deepen the knowledge about each sector of activity and region.

The fact that GHRM is an emerging and unexplored concept, coupled with the lack of availability and time of the target audience, may have caused resistance and limited the participation of organizations in this study.

It is understood that adopting a mixed methodology could bring interesting results, allowing the debate of the workers' perspective regarding their involvement and green organizational culture compared with the perspective of the middle and top levels of the organization. A study with this methodological and significantly more comprehensive design would allow us to achieve a high representativeness.

On an even deeper scale, it is understood that with more extended studies and more resources, it would be interesting to conduct a survey of GHRM practices at the European or global level, as well as to identify the constraints and challenges that organizations in other national realities face for its implementation. It is anticipated that this gain of awareness of GHRM at a global level, resulting from the continuity of future research on the subject, may allow organizations to develop more rigorous and adjusted strategies, which promote the maximization of environmental results internal and external to organizations, in a logic of environmental co-responsibility.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. General table characterizing the participants.

Interviewee	Interviewee's Company Sector of Activity Main CAE (CAE-Rev.3)	Nº Workers in Portugal Nº Workers in Portugal Number of Workers in Portugal	Location	Company's Year Foundation	Interviewee's Role	Educational Background	Educationa Level	Age	Gende	Tenure
I1	Manufacture of chemical products and manufactured fibers, except pharmaceutical products	<1000	Porto	1917	HR Director	Human resources	PhD	41–50	F	1 y 11 m
I2	Financial services activities, except insurance and pension funds	>1000	Lisboa	2000	L&D Coordina-tor	Engineering	Degree	41–50	F	7 y 10 m
I3	Computer programming and consultancy and related activities	>1000	Lisboa	1967	Sustainability Chief	Environmental engineering	Master	41–50	F	1 y 10 m
I4	Financial services activities, except insurance and pension funds	>1000	Braga	2007	HR Director	Human resources	Master	31–40	M	10 y 5 m

Table A1. *Cont.*

Interviewee	Interviewee's Company Sector of Activity Main CAE (CAE-Rev.3)	Nº Workers in Portugal Nº Workers in Portugal Number of Workers in Portugal	Location	Company's Year Foundation	Interviewee's Role	Educational Background	Educationa Level	Age	Gende	Tenure
I5	Head office and management consultancy activities	>1000	Lisboa	1999	HR Business Partner	Psychology	Master	31–40	M	1 y
I6	Other consulting, scientific, technical, and similar activities	<1000	Braga	1999	HR Develop-ing manager	Human resources	Degree	31–40	F	21 y 9 m
I7	Waste collection, treatment, and disposal; material recovery	<1000	Porto	2008	HR Director	Geology	Degree	41–50	M	4 y 1 m
I8	Waste collection, treatment, and disposal; material recovery	<250	Porto	1982	HR Chief	Human resources	Degree	41–50	F	21 y 7 m
I9	Postal and courier activities	>1000	Lisboa	2019	HR Director	Human resources	Degree	31–40	M	6 m
I10	Manufacture of electrical equipment	>1000	Porto	1948	Environment, Health and Safety Chief	Human resources	Degree	31–40	F	13 y 7 m
I11	Trade, maintenance and repair of motor vehicles and motorcycles	<1000	Porto/Lisboa/Aveiro	1946	HR Business Partner	Human resources	High School	up to 30	F	5 y 3 m
I12	Manufacture of other non-metallic mineral products	<500	Aveiro	1964	HR Specialist	Sociology	Master	up to 30	F	2 y 10 m
I13	Manufacture of rubber and plastic products	<250	Porto	2006	Developing manager	Environmental management	Degree	41–50	F	1 y 9 m
I14	Financial services activities, except insurance and pension funds	<250	Porto	2008	People and Culture manager	Psychology	Degree	41–50	F	9 y 4 m
I15	Wholesale trade (including agents), except motor vehicles and motorcycles	>1000	Setúbal	1953	HR Director	Human resources	Master	51–60	M	1 y 5 m

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The Assessment of Green Business Environments Using the Environmental–Economic Index: The Case of China

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Abstract: The quality of a country's business environment speaks volumes about its government's capacity and competitiveness. Unfortunately, the current system only evaluates countries and cities, overlooking the business environments of individual provinces. To address this issue, this study utilizes a green and sustainable development approach to evaluate the business environments of 30 provinces/municipalities in China. By incorporating ecological and environmental protection and sustainable development indicators, a novel green business environment index is constructed and analyzed to determine its impact on macroeconomic sustainable development and micro-enterprise operation. Taking into account the business environment index established by the World Bank and other organizations, this evaluation system adds ecological and environmental indicators specific to each province/municipality in China from the year 2011 to 2020. The result is a provincial green business environment evaluation index system consisting of 5 primary indicators and 30 secondary indicators. Principal component analysis (PCA) is then applied to rank the green business environment for each province/municipality. Furthermore, the overall green business environment of the Eastern region is superior to that of the Central and Western regions, highlighting the uneven development of the business environment in China.

Keywords: green business environment; sustainable economic development; Spatial Dubin Model

1. Introduction

The UN's 2030 Agenda emphasizes the importance of promoting high-quality economic growth through the establishment of a green business environment (GBE). Achieving a balance between economic and environmental concerns requires a deep understanding of the sustainable development process. The concept of GBE is broad, and its theoretical consensus is still being developed. It is often associated with Green GDP, Green and Low Carbon Economy, Green and Sustainable Development, and Green Total Factor Productivity. Research shows that a greener business environment enhances a country's growth potential. For instance, Zhao et al. used China's solid waste rate as a measure of its ecological baseline and found that a greener business environment boosts economic growth [1].

Optimizing and protecting the corporate environment serve different, but equally vital, purposes. The business environment evaluation index was considerably improved after the National Development and Reform Commission (NDRC) incorporated the ecological environment as an evaluation indicator in 2020. Generally speaking, one of the subsystems reflecting the business environment is the ecological environment [2]. The greatest strategy to maintain the business climate is to build the economy on the foundation of protecting the natural environment. In line with this perspective, Song and Mei suggest that ecological welfare performance measures the relationship between ecological resource inputs and welfare outputs, reflecting the sustainable development status of a region [3].

Creating a healthy balance between the market and the government is crucial for a successful economy. Alongside laws, regulations, supervisory systems, and financial

support policies, it is important to implement green support policies like researching and developing green technology, digitizing the green industry, and enforcing laws and regulations. The government plays a critical role in directing, administering, and ensuring the success of the green economy, while businesses develop green technology and make informed decisions with the help of the government's business platform. This leads to less pollution and better energy conservation. To achieve a GBE, the entire society must work together, including the government, businesses, and enterprises. Industries and businesses should establish GBE strategies considering the synergy of economic gains and environmental protection [4].

This study introduces the GBE Evaluation Index and incorporates the notion of sustainable and green development into the existing business environment evaluation index for future studies. The GBE emphasizes rational resource management and environmental protection to achieve sustainable development and high-quality economic growth, rather than simply combining green development and the business environment. Optimizing the creation of a GBE can benefit market participants' commercial behavior, increase enterprise competitiveness, promote enterprise transformation, and coordinate the high-quality, low-carbon development of enterprises. In China, a GBE assessment index with Chinese characteristics should be developed to measure the business environment along with the current business environment evaluation index.

2. Literature Review

2.1. Sustainable Development Goals (SDGs) Compliance

The United Nations identified 17 Sustainable Development Goals (SDGs) in 2015, which encompass the three dimensions of sustainable development: social, economic, and environmental. This study considers economic development, foreign investment, fixed asset investment, the ability to raise capital, financing capacity, and transport efficiency as indicators of the economic environment and population, inflation, disposable income, employment, social security level, and wage level as indicators of the social environment, as related works [5–7] have suggested. Achieving the SDGs is a global responsibility, and a healthy business climate can accelerate a resilient, inclusive, and sustainable recovery. The study also highlights the significance of renewable energy, land use, digital technologies, and high-quality education. Quality education indicators include inputs of education, higher education, and cultural atmosphere, while health insurance and social security level indicators are also vital. Clean energy indicators focus on power consumption, land use indicators consider land cost, and digital technology indicators focus on enterprise digitization.

2.2. Green Economic Perspective

The concepts of green economy, green growth, and green development have gained significant attention globally. The United Nations defines a green economy as promoting sustained, inclusive, and sustainable economic growth; full and productive employment; and decent work for all. Fair distribution is a word that comes up frequently in the context of the green economy [8]. Thus, we use "wage level" as the metric with which to measure fair distribution.

The green growth approach, according to the OECD, aims to promote economic growth and prosperity while preserving the availability of natural resources and environmental services that are vital to our well-being. Investment, innovation, and jobs should be the catalysts for new kinds of economic growth [9]. Therefore, inventions and patents, technological input, and technological innovation are grouped as technology and innovation indicators, while employment is used as an employment indicator.

In October 2008, the "Global Green New Deal" initiative was introduced as a response to the economic crisis of the time. This initiative gave rise to the idea of green development theory. The theory suggests that nations should prioritize long-term development when creating economic stimulus plans, establishing green institutions, promoting sustainable

development, and working towards global green improvements [10]. China formally introduced the concept of green development in 2015, with the release of the white paper "China's Green Development in the New Era" in 2023. This publication reflected the emergence of ecological civilization. Green development frequently involves industry and towns [11], and this study examines the effects of GBE measures on green development, with GDP being a key macroeconomic indicator of industrialization.

2.3. Environmental, Social, and Governance (ESG) Framework

Currently, more and more businesses are not only considering macroeconomic and environmental factors, but also focusing on eco-friendly operations. A prime example of this is the emergence of environmental, social, and governance (ESG) evaluation indicators. Chinese scoring agencies like Wind, MSCI, FTSE Russell, Sustainalytics, etc., have developed ESG evaluation indicators. ESG assesses environmental factors, such as wastewater, exhaust emissions, and energy usage, to determine how a company is performing in terms of sustainability [12]. Additionally, Song and Mei surveyed 30 provinces, autonomous regions, and municipalities using the environmental resource consumption and human development index [3]. Thus, we adopt green environmental indicators, including power consumption, environmental protection expenditure, waste disposal, air pollution, and living environment, in this research.

With the growing importance of the ecological economy and green environmental conservation, many organizations have reevaluated their business philosophies and models. To ensure long-term growth and profitability, companies now recognize the need to adopt green mindsets and business models. This involves considering internal and external factors, prioritizing shareholders and employees, taking on social responsibility, and operating sustainably. ESG is a framework used to evaluate a company's performance in these areas.

This research introduces the GBE assessment index, which is a combination of previous evaluation indices and a new ecological environment evaluation index that is tailored to Chinese provinces. The existing evaluation indices do not account for essential factors that affect the business environment, such as education and technological progress. The GBE Evaluation Index includes five components: economic environment, government environment, social environment, technical environment, and green environment.

2.4. Related Theories of Government Governance

The business environment plays a crucial role in the sustainable economic and social development of a country, and is an essential indicator of its overall strength and competitiveness. It also reflects the government's ability to govern efficiently. Evaluating the business environment helps to determine not only how well it is performing in a particular economy, but also how effectively the government is fulfilling its public service obligations [12]. For China, establishing an appropriate evaluation index system is vital for accurately assessing the efficiency of local government governance [13]. Indicators like government revenue scale, government balance, and tax are used to assess the government environment.

2.5. Green Business Environment Evaluation Index (GBEEI)

The development balance between Chinese provinces and cities is uneven, as per the country's overall recovery. Long-term globalization is now leaning towards regionalization or localization [14,15]. Bigger cities with more external access experience a slower recovery, while their surrounding areas bounce back more quickly. Improving the business environment is now a top priority, and the government's resilience is critical during this time. To achieve this, the government must concentrate on increasing social and psychological expectations, boosting development confidence, enhancing consumption, and improving the business environment. This aligns with the current vision of economic development in China, which was explored in the GBE study.

In China, the government is prioritizing the improvement of the business environment to support sustainable growth. However, the current literature only offers evaluation indicators from either a business environment or sustainable development perspective, without combining the two. Furthermore, the available indicators for assessing the business environment are found mostly at the national level or in international cities, resulting in a lack of provincial indicators with which to compare and identify gaps. This also makes it challenging for the government to enhance the business environment for better corporate satisfaction.

The data utilized in this study are public and accessible. The "wage level" indicator utilizes data from the Economic and Social Development Statistics Bulletin (2011–2020) of each province, whereas the "capability to acquire capital" and "financing capacity" indicators utilize data from the Wind Financial Terminal Database. The rest of the data were sourced from the China Statistic Yearbook (2012–2021). Table 1 shows the description of the green business environment (GBE) evaluation index, including 29 indicators.

Table 1. The green business environment evaluation index.

Dimensions	No.	Indicators	Indicator Description	Indicator Explanation
Economic Environment	X11	Economic Development	Gross regional product index (Previous year = 100)	Econometric development level
	X12	International Trade	Total amount of import and export of goods (USD 1000)	Level of foreign trade
	X13	Foreign Investment	Actual use of foreign direct investment (USD 10,000)	Increased confidence in the investment environment
	X14	Fixed Asset and Investment	Fixed asset investment price index (previous year = 100)	Whether the enterprise is optimistic about future economic development
	X15	Enterprise Digitization	The proportion of enterprises with e-commerce transaction activities (%)	The degree of digitalization of the enterprise
	X16	Capability to Acquire Capital	Number of listed companies	The quantity and quality of listed companies determine the economic scale and height of a province
	X17	Financing Capacity	Social financing scale	Economic attractiveness and financing capacity of a province
	X18	Transport Efficiency	Cargo turnover (billion ton-kilometers)	Logistics development status
Government Environment	X21	Government Revenue Scale	The ratio of local general budget revenue to GDP (CNY ten billion)	The government's ability to improve the quality of the provinces' business environments via financial support
	X22	Government Balance	Local government's general budget revenue minus public service expenditure (%)	The ability of the government to coordinate the stable development of the economy
	X23	Tax	The ratio of tax revenue to GDP (%)	The economic status of each province
	X24	Land Cost	The ratio of land purchase cost to land purchase area (CNY/square meter)	The land cost of the enterprise

Table 1. *Cont.*

Dimensions	No.	Indicators	Indicator Description	Indicator Explanation
Social Environment	X31	Population	Urban population density (person/square kilometer)	Provinces' economic attractiveness
	X32	Inflation	Consumer price index (previous year = 100)	Purchasing power
	X33	Disposable Income	Per capita disposable income of residents (CNY)	The wealth of the people
	X34	Employment	Urban registered unemployment rate (million people)	Measures slack labor capacity
	X35	Social Security Level	Number of participants in basic medical insurance (million people)	People's living standards
	X36	Wage Level	Monthly minimum wage standard of each province (The highest grade, CNY)	Reflects social employment and income thresholds
Technical Environment	X41	Input of Education	Education expenditure divided by local general public budget expenditure (CNY 100 million)	Related to the quality of citizens and the long-term development of the country
	X42	Higher Education	The number of colleges and universities or institutions	Conducive to personnel training
	X43	Inventions and Patents	Number of effective invention patents (pieces)	Conducive to the progress and development of science and technology
	X44	Technology Input	Technology market turnover per unit of GDP (%)	Transformation and upgrading of economic structure
	X45	Technological Innovation	The number of new product development projects (pieces)	Promotion of social development
	X46	Cultural Atmosphere	Public library holdings per capita ((books per person))	Improvement of humanistic quality
Green Environment	X51	Power Consumption	Electricity consumption per CNY 100 million of GDP	Consumption of resources and the environment
	X52	Environmental Protection Expenditure	Environmental protection expenditure in local government fiscal expenditure (CNY 100 Million)	Degree of protection of resources and environment
	X53	Waste Disposal	Harmless treatment capacity of municipal solid waste (10,000 tons)	Reduces environmental pollution and waste of resources
	X54	Air Pollution	Emissions of SO_2, NO_2, CO, O, PM_{10}, and $PM_{2.5}$	Degree of pollution to the environment Chinese National Ambient Air Quality Standards (CNAAQS)
	X55	Living Environment	Parks and green areas per capita (square meters/per person)	Improvement of human living environment

3. Methodology

3.1. Principal Component Analysis

In the areas of economics, management, geography science, and other fields, principal component analysis (PCA) has been widely used to analyze non-random and random variable data [9]. Additionally, the PCA approach has been used in the field of the business

environment because of its qualities and the advantage of producing a comprehensive score based on many indications [16]. The PCA method involves using statistical techniques to analyze a set of criteria and extract common components [17]. By identifying representative elements in multiple criteria, PCA achieves dimension reduction. Additionally, it groups similar criteria into major components to test the relationships between variables. PCA reduces the complexity of interconnected variables or indices by creating a new combination with fewer, and unrelated, indicators or variables. To accomplish this, the PCA process involves several steps. The first step is variable standardization, which employs the z-score approach, expressed as follows in Equation (1).

$$Z_{ij} = \frac{X_{ij} - \overline{X}_j}{\sigma_j} \tag{1}$$

In order to assess the suitability of variables for PCA, the Kaiser–Meyer–Olkin (KMO) index and Bartlett's test of sphericity are commonly utilized. This study specifically employed Bartlett's test of sphericity with a significance level of $p < 0.001$ to examine the inter-correlation among variables, while the KMO index was used to measure sample adequacy and evaluate the validity of the PCA. The subsequent steps involved calculating the number of primary components based on their variance contribution rates and eigenvalues, determining the expression for the linear combination of primary components, and using the eigenvalues as weights to compute the composite index. To simplify the evaluation of the green business environment in provinces and municipalities, this thesis adopted the PCA method to reduce the number of indicators to 29 and obtain an overall score.

3.2. Spatial Econometrics

The first rule of spatial geography states that the strength of the correspondence between features is affected by distance. The components are more closely linked when the geographic distance is less [18]. Additionally, it is evident that the business climate and regional development are spatially correlated. However, traditional economic models are biased and do not consider spatial effects. Therefore, due to the variation in the business climate across provinces and municipalities in China, which may impact spatial effects, a spatial econometric model was used based on previous research [19]. In this study, two components, namely, the spatial correlation test and spatial econometric modeling, are utilized for the spatial econometrics procedure. Before implementing the spatial econometric model, it is necessary to measure the spatial dependence of the explained and explanatory variables. The investigation in this thesis uses both global space autocorrelation and local space autocorrelation as perspectives. The Global Moran's I is presented in this manner (Equation (2)).

$$\text{Moran}'\text{s I} = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \overline{x})\left(x_j - \overline{x}\right)}{S^2 \cdot \left(\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\right)} \tag{2}$$

In this study, a Moran index scatterplot is utilized to display the local spatial autocorrelation. The empirical investigation of this paper utilizes the economic distance weight matrix, as it can indicate the spatial correlation between provinces with high economic proximity. Additionally, the geographic distance weight matrix is used for the robustness test to prevent any bias in the findings from a single matrix estimate. Based on the above analysis, the economic distance weight matrix (W_1) and geographic distance weight matrix (W_2) are constructed in the following manner (Equations (3) and (4)):

$$W_1 = \begin{cases} \dfrac{1}{\frac{1}{n}\left|\sum_{2011}^{2020} PGDP_i - \sum_{2011}^{2020} PGDP_j\right|2}, \; i \neq j \\ 0, \; i = j \end{cases} \tag{3}$$

$$W_2 = \begin{cases} \frac{1}{d_{ij}}, \ i \neq j \\ 0, \ i = j \end{cases} \quad (4)$$

For modeling purposes, the regional per capita GDP (*PGDP*) and the number of years (n) are represented by *PGDP* and n, respectively. The distance between the geographic centers of regions i and j is represented by d_{ij}. It is important to normalize both spatial weight matrices before the modeling process. To describe spatial impacts, researchers often use the Spatial Lag Model (SLM) and the Spatial Error Model (SEM) after examining spatial correlation. The Spatial Dubin Model (SDM) is a typical form of both the SLM and the SEM [18]. The SDM analyzes the effects of neighboring independent variables on their own dependent variables, as well as the spatial spillover effect of dependent variables in adjacent regions. Although the SDM is well-known for analyzing spatial spillover effects, its effectiveness requires further investigation. The following are general representations of the SDM (Equation (5)):

$$Y_{it} = \rho W Y_{it} + \alpha X_{it} + \theta W X_{it} + \xi_{it} + \varphi_{it} + \varepsilon_{it} \quad (5)$$

This study aims to use spatial econometric models to determine if whether there is a spatial effect of the GBE in the 30 provinces and municipalities of China. In the models, α represents the corresponding parameter and denotes the random error term. Here, ρ and θ are spatial regressive coefficients; W represents the spatial weight matrix; and ξ_{it} and φ_{it} represent spatial and time effects, respectively. If $\theta = 0$, then SDM is equivalent to SLM. If $\theta + \rho\alpha = 0$, then SDM is equivalent to SEM.

4. Empirical Result

4.1. Result of Principal Component Analysis

To determine whether the variables are suitable for the principal component analysis (PCA) method, a computation process was performed using the KMO Index and Bartlett's Test. The KMO statistical value for the years 2011–2020 was greater than 0.60, while the significance of Bartlett's test for all years was less than 0.05. These results indicated that the data were appropriate for PCA. To identify the main components, we used the data-driven principle and applied the PCA method. By combining all the indicators, we obtained a better understanding of the overall situation. After examining the variance contribution and conducting the applicability test for PCA, we found that five components had initial eigenvalues greater than 1, which meant that they could explain 84.54% of the total variables. Therefore, we chose these five components for further analysis.

To calculate the GBE Evaluation Index in China from 2011 to 2020, we used the principal components' eigenvalues as weights to determine the composite index. Table 2 displays the results of this process. By averaging the scores of each province over the ten-year period, we found that GD, SH, JS, BJ, and ZJ were the top 5 provinces and municipalities out of 30. On the other hand, XJ, GZ, NX, GS, and QH ranked as the lowest five provinces and municipalities.

Table 2. The GBE scores for provinces and municipalities (2011–2020).

ID No.	Province (PR)		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	Beijing	BJ	69.61	75.96	73.39	69.86	76.65	72.53	81.16	80.04	70.73	72.58
2	Tianjin	TJ	53.20	50.95	49.25	54.83	57.13	50.81	48.64	45.62	49.55	45.61
3	Hebei	HEB	42.70	44.38	43.29	41.04	41.19	41.52	42.97	44.28	46.28	46.99
4	Shanxi	SX	37.31	37.39	36.39	33.43	34.63	33.36	34.99	35.99	37.63	37.10
5	Neimenggu	NM	41.49	40.74	38.61	33.58	37.25	33.45	35.76	36.90	35.41	36.26
6	Liaoning	LN	56.30	57.89	50.68	49.16	44.11	39.79	38.58	43.95	41.34	39.10
7	Jilin	JL	36.26	36.24	33.82	33.94	35.72	32.06	33.15	35.38	32.83	32.58
8	Heilongjiang	HL	35.59	39.36	34.77	31.51	32.63	32.23	30.56	32.85	36.21	29.58
9	Shanghai	SH	77.55	76.35	72.91	82.16	81.91	85.18	80.91	79.13	84.57	82.12
10	Jiangsu	JS	75.16	75.18	78.64	79.70	73.13	72.38	72.12	74.92	69.99	76.73
11	Zhejiang	ZJ	67.33	60.35	71.02	72.06	66.97	68.50	68.95	71.18	68.79	73.72
12	Anhui	AH	43.67	41.57	41.71	42.71	42.08	44.18	44.80	42.33	41.02	42.03
13	Fujian	FJ	43.52	42.08	43.79	43.60	42.71	45.18	44.39	40.51	45.15	44.03
14	Jiangxi	JX	34.24	35.35	36.90	36.97	38.78	40.14	37.70	38.07	39.59	39.48
15	Shandong	SD	57.98	56.12	61.09	56.91	56.15	56.61	55.87	59.40	54.22	59.40
16	Henan	HA	41.52	42.77	41.78	40.98	42.14	43.30	41.50	43.71	44.97	44.68
17	Hubei	HUB	42.55	41.58	40.55	42.58	42.57	46.52	44.02	41.69	41.82	40.31
18	Hunan	HUN	39.46	38.20	39.08	40.26	39.48	41.96	38.64	38.71	39.92	40.02
19	Guangdong	GD	79.93	80.73	91.45	89.70	85.57	89.60	88.75	95.60	91.48	98.58
20	Guangxi	GX	33.59	33.62	33.10	35.33	32.87	34.10	33.27	33.15	33.43	31.82
21	Hainan	HN	34.79	34.73	31.00	34.91	34.35	40.87	37.35	33.33	35.40	34.67
22	Chongqing	CQ	38.82	39.42	37.98	37.31	36.64	37.66	38.77	36.29	36.40	36.64
23	Sichuan	SC	41.20	44.03	45.50	42.58	42.46	44.28	42.86	42.37	44.04	43.66
24	Guizhou	GZ	32.06	32.84	31.07	32.29	33.61	33.01	35.84	33.08	34.72	33.59
25	Yunnan	YN	34.27	35.36	35.23	36.06	36.36	35.68	34.33	32.64	34.85	31.36
26	Shaanxi	SN	35.42	37.49	37.04	36.35	36.80	36.55	38.52	36.55	39.60	37.59
27	Gansu	GS	27.95	28.67	28.25	27.97	32.11	28.93	31.42	30.27	30.79	30.92
28	Qinghai	QH	29.16	26.79	27.86	28.99	32.33	29.11	28.80	27.15	26.57	25.84
29	Ningxia	NX	33.13	27.50	29.92	29.67	29.85	28.52	33.36	32.10	29.02	30.84
30	Xinjiang	XJ	34.23	36.35	33.93	33.55	31.80	31.99	32.01	32.79	33.64	32.16

4.2. Spatial Correlation Test Results

From 2011 to 2020, Moran's I value for sustainable economic development was consistently positive and passed a significant level test of 5%. This suggests that there are significant spatial agglomeration and spillover effects associated with the spatial distribution of regional sustainable economic development and the Green Business Environment. To verify the spatial clustering characteristics of the Global Moran's I, the Local Moran's I was used. Since there was a large amount of data, a Moran scatter plot was used to show the Local Moran's I. In the Local Moran's I scatter plot (Figure 1), the first quadrant represents a High–High agglomeration area (HH), the second quadrant is a High–Low agglomeration area (HL), the third quadrant indicates a Low–Low agglomeration area (LL), and the fourth quadrant is a Low–High agglomeration area (LH). A High–High agglomeration area means that the sample itself is high and the sample around it is also high, while a Low–Low agglomeration area means the sample itself is low, with a low sample neighborhood around it.

There are examples of the Local Moran scatter plot that display the spatial clustering of regional sustainable economic development in the years 2011 (Figure 2a) and 2020 (Figure 2b). It is clear that the majority of provinces (municipalities) have their regional sustainable economic development concentrated in the first quadrant (High–High agglomeration areas) and the third quadrant (Low–Low agglomeration areas), indicating a significant, positive spatial correlation. The numbers shown in Figure 2a,b correspond to each province's ID number, as referenced in Table 2.

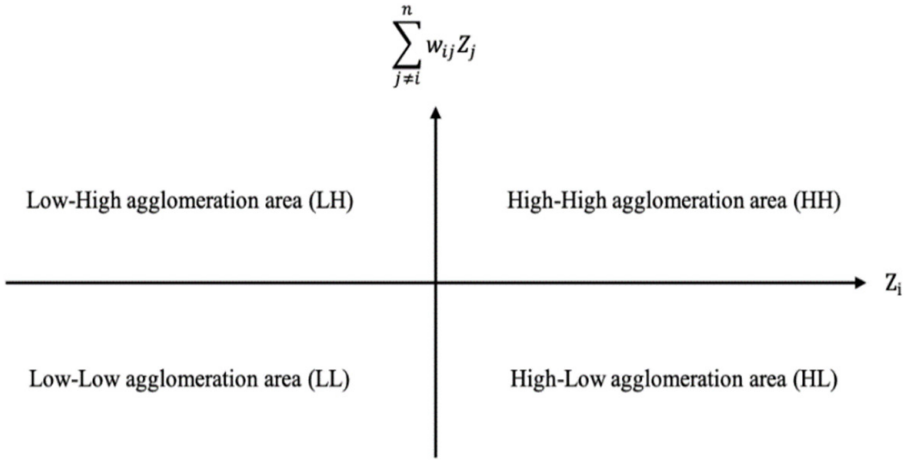

Figure 1. Schematic of the local Moran's I's four quadrants.

According to the results, we can find examples of the Local Moran scatter plot that display the GBE Evaluation Index spatial clustering for the years 2011 and 2020, represented in Figure 3a,b, respectively. Let us focus on Figure 3a. The first quadrant illustrates provinces with high GBE scores surrounded by other provinces with similarly high GBE scores, while the third quadrant shows lower GBE scores surrounding provinces with equally low GBE scores. By analyzing the province ID number, it becomes evident that the Eastern region in China is primarily concentrated in the "High–High" agglomeration areas, whereas the Central and Western regions are predominantly located in "Low–Low" agglomeration areas.

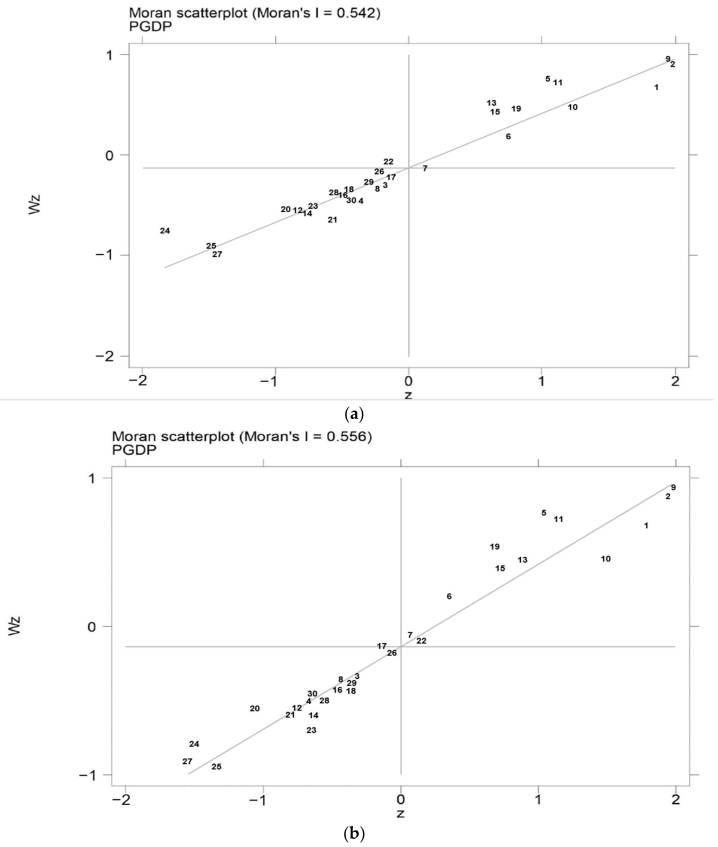

Figure 2. (**a**) Local Moran scatter plot for regional sustainable economic development (2011). (**b**) Local Moran scatter plot for regional sustainable economic development (2020).

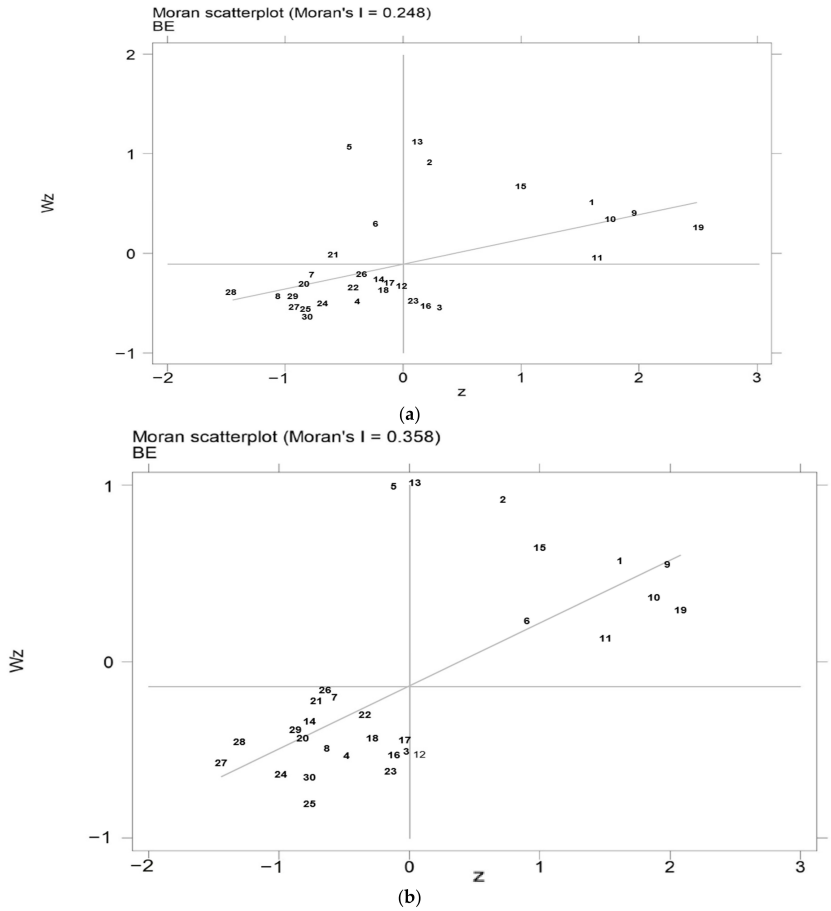

Figure 3. (**a**) Local Moran scatter plot for regional GBE evaluation index (2011). (**b**) Local Moran scatter plot for regional GBE evaluation index (2020).

4.3. Statistical Test Results for Model Selection

This study examines the impact of the green business environment on sustainable economic development in different areas. The spatial panel model has been divided into two distinct effect models, namely, fixed-effect and random-effect, based on differences in residual component decomposition. To determine the best model for the analysis, we refer to the results of Hausman's test. The null hypothesis was rejected at a significance level of 1%, which is indicated by the statistic in Table 3. This means that the fixed-effect model is the optimal choice. If the statistical software renders a *p*-value of 0.000, it means that the value is very low, with many instances of "0" before any other digit.

Secondly, based on the results of the log-likelihood (LR) test, it is evident that the double-fixed model is appropriate, as the null hypothesis regarding the joint significance of spatial fixed effects is rejected. Additionally, both the robust LM spatial lag and the robust LM spatial error models pass the significance test, indicating that both the spatial lag and spatial error models can be applied effectively.

Thirdly, in a spatial regression analysis, SDM, SLM, and SEM can be utilized. However, it is important to identify the model that best fits the data. The applicability of SDM was tested using the Wald and LR tests. The estimated results in Table 4 demonstrate that the SDM model could be reduced to SLM and SEM models. Both null hypotheses were rejected and passed the significance test. As a result, this study combines the aforementioned analyses to select the SDM model under double-fixed effects as the final interpretation model for spatial regression.

Table 3. Statistical test results for model selection.

Type of Test	Null Hypothesis	Statistic	*p*-Value
Hausman test	The individual effect has no correlation with the regression variable	36.59	0.000
LR test	Spatial fixed-effect nested within double fixed-effect	68.82	0.000
	Time fixed-effect nested within double fixed-effect	651.55	0.000
LM-Spatial error	No spatial correlation between error terms	21.65	0.000
Robust LM-Spatial error		22.81	0.000
LM-Spatial lag	No spatial correlation between lag terms	13.61	0.000
Robust LM-Spatial lag		14.77	0.000

Table 4. Wald test and LR rest (double fixed-effect).

Statistical Tests	SLM vs. SDM		SEM vs. SDM	
	Z-Value	*p*-Value	Z-Value	*p*-Value
Wald test	51.82	0.000	51.60	0.000
LR test	48.01	0.000	47.39	0.000

4.4. Spatial Regression Results

This study used the economic distance weight matrix (W_1) and the SDM model to investigate the geographical effects of a GBE on sustainable economic development. For the robustness test, the geographic distance weight matrix (W_2) was also utilized. Table 5 presents the outcomes. With the exception of human capital, all of the control variables were statistically significant. According to the coefficient of GBE, which was 0.1026 and significant at 1%, there is a commensurate improvement in sustainable economic growth of 0.1026% for every 1% increase in the green business environment.

On one hand, creating a supportive environment for green businesses can lead to reduced operational costs, encourage innovation, and expand the market. On the other hand, it may also attract more foreign investment, which can boost long-term economic growth. Furthermore, optimizing a green business environment as an "economic neighbor" has a positive impact on the sustainable economic development of the province or municipality, as evidenced by the coefficient of spatial interaction (***W****lnGBE) of 0.2362, which is statistically significant at the 1% level.

All geographical interactions between the control variables were also significant, with the exception of foreign direct investment. Notably, the spatial weight coefficient was −0.0296 and significant at 1%, while the coefficient of the primary influence of environmental regulation was −0.0069 and exhibited 5% statistical significance. It is conceivable that environmental rules, which could operate as external impediments to economic expansion, are to blame because they have a direct bearing on expenditure and cost. More specifically, excessive environmental protection costs will harm sustainable economic growth.

The spatial regression results from the SDM model are displayed in Table 5 together with the geographic distance weight matrix (W_2) for robustness testing. The results obtained using the economic distance weight matrix were consistent with the main effect and geographical weight coefficients of the GBE, which were 0.0717 and 0.5582, respectively, and significant at 5% and 1% for the core explanatory factors. Using geographic distance as the spatial weight matrix also resulted in a greater significance of the positive geographical spillover effect than the previously suggested model for spatial effect. This can show how the spatial spillover effect of the GBE had a major influence on the provinces and municipalities that are nearest to one another geographically. The robustness of the empirical findings was demonstrated by the control variable coefficients, which had nearly the same signs and significance as the preceding ones.

Table 5. Results of spatial econometric model.

Variable	OLS	Spatial Weight Matrix (W_1)	Spatial Weight Matrix (W_2)
	Model I	**Model II**	**Model III**
lnGBE	0.6573 ***	0.1026 ***	0.0717 **
	(0.070)	(0.031)	(0.030)
lnFC	0.2766 ***	0.0655 ***	0.0892 ***
	(0.069)	(0.014)	(0.014)
lnHC	2.4981 ***	−0.0039	0.0946
	(0.223)	(0.102)	(0.100)
lnFDI	−0.0145	0.0106 ***	0.0068 *
	(0.017)	(0.004)	(0.004)
lnER	0.0022	−0.0069 **	0.0013
	(0.018)	(0.003)	(0.003)
lnIS	0.4112 ***	−0.1658 ***	−0.1390 ***
	(0.112)	(0.039)	(0.037)
*W**lnGBE		0.2362 ***	0.5582 ***
		(0.084)	(0.207)
*W**lnFC		−0.0666 *	0.5013 ***
		(0.039)	(0.107)
*W**lnHC		0.6280 **	1.8581 **
		(0.278)	(0.769)
*W**lnFDI		0.0151	−0.0935 **
		(0.011)	(0.037)
*W**lnER		−0.0296 ***	0.0635 ***
		(0.008)	(0.023)
*W**lnIS		0.4800 ***	−0.4939
		(0.113)	(0.341)
ρ		0.2095 **	0.4866 ***
		(0.103)	(0.140)
N	300	300	300
R^2	0.7166	0.7892	0.3194
Log-L		674.8425	686.8714

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively—standard errors are in parentheses.

4.5. Spatial Effect Decomposition

The spatial model is capable of identifying the unique characteristics of spatial units in different provinces (municipalities) [20]. However, when spatial autocorrelation is considered, the explanatory variable coefficients in the SDM model may not accurately reflect the impact of independent factors on dependent variables [21]. In order to evaluate the spatial spillover effects, it is important to determine the direct, indirect, and total effects. Specifically, the indirect effect refers to the possible spillover effect that independent factors may have on sustainable economic development, while the direct effect represents the impact of changes in independent variables on sustainable economic growth within a fixed spatial unit.

Table 6 demonstrates that a green business environment has a direct and significantly positive impact on local sustainable economic development under the economic distance weight matrix (Model II). This implies that optimizing a green business environment can effectively raise the standards of local economic development. A convenient business environment can help to attract and nurture elite individuals and businesses. By promoting clustering and technology spillover effects, enhancing the green business environment can lead to high-quality development and economic sustainability. This eventually results in improved product quality and competitiveness. Moreover, strengthening the green business environment has a significant and positive indirect effect. This shows that the positive spatial spillover effects enhance the economic sustainability of municipalities and their neighboring provinces.

Both the direct and indirect effects of the green business environment were notably positive in Model III with the geographic distance weight matrix. This demonstrates how enhancing the environment for green business benefits nearby neighborhoods as well as the sustainable economic development of the region. It is important to note that Model III had an indirect effect on the green business environment, which was higher than Model II's coefficient. The coefficient for Model III was 1.991, while Model II's coefficient was 0.3162. This means that the spatial effects of the green business environment have a greater impact on provinces and municipalities that are closer in terms of geography than in terms of the economy. In other words, the closer provinces and municipalities are to each other, the more significant their influence on sustainable economic development becomes due to their increasing influence of the green business environment. As the geographic distance between provinces and municipalities increases, the spatial spillover effect gradually decreases.

Table 6. Result of spatial effect decomposition.

Variable	Model II			Model III		
	Direct Effect	**Indirect Effect**	**Total Effect**	**Direct Effect**	**Indirect Effect**	**Total Effect**
lnGBE	0.1122 ***	0.3162 ***	0.4284 ***	0.0972 ***	1.1991 **	1.2963 **
	(0.031)	(0.108)	(0.117)	(0.032)	(0.532)	(0.544)
lnFC	0.0618 ***	−0.0754 *	−0.0136	0.1105 ***	1.0723 ***	1.1828 ***
	(0.012)	(0.043)	(0.046)	(0.017)	(0.365)	(0.377)
lnHC	0.0248	0.7588 **	0.7836 **	0.1794	3.7181 **	3.8975 **
	(0.111)	(0.319)	(0.350)	(0.123)	(1.834)	(1.898)
lnFDI	0.0116 **	0.0221	0.0337 *	0.0035	−0.1754 **	−0.1719 *
	(0.005)	(0.016)	(0.018)	(0.005)	(0.087)	(0.091)
lnER	−0.0086 **	−0.0376 ***	−0.0462 ***	0.0036	0.1326 *	0.1362 *
	(0.004)	(0.011)	(0.012)	(0.004)	(0.073)	(0.075)
lnIS	−0.1470 ***	0.5514 ***	0.4044 **	−0.1598 ***	−1.1191	−1.2789 *
	(0.040)	(0.155)	(0.172)	(0.044)	(0.706)	(0.734)

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

4.6. Regional Heterogeneity Analysis

This study aims to examine how the spatial spillover effect of the GBE affects the sustainable development of the regional economy in China. We consider the varying economic foundations and resource allocation across China's eastern, central, and western regions. Table 7 provides a detailed breakdown of the spatial effect and the estimation results.

The research shows that a green business environment (lnGBE) has a positive and direct impact on sustainable economic development (0.1268 **), particularly in the eastern regions. This means that improving the local GBE will positively impact sustainable economic development. However, the indirect effect of GBE (0.1442) is insignificant, which suggests that improvements to the green business environment in neighboring municipalities or provinces will not have an impact on sustainable economic development. To put it simply, a focus on improving the GBE in the Eastern region will primarily benefit the long-term growth of the local economy.

In contrast, both direct and indirect benefits in the central and western regions were noteworthy, at 1%. The improvement of the GBE in these two regions, as well as in their neighboring regions, has a significant impact on sustainable economic development, especially in comparison to other regions. These findings align with some research [22,23] regarding the effects of various regional business environments on sustainable economic development. Overall, it can be concluded that the development of a green business environment has a positive impact on sustainable economic growth, and this impact is more significant in regions with less-developed business environments.

Table 7. Heterogeneity analysis of spatial effects in various regions.

Region	Variable	Direct Effect	Indirect Effect	Total Effect
Eastern Region	lnGBE	0.1268 **	0.1442	0.2710 ***
		(0.051)	(0.108)	(0.100)
	lnFC	0.0761 ***	0.2134 ***	0.2895 ***
		(0.028)	(0.062)	(0.065)
	lnHC	0.0572	0.1390	0.1963
		(0.183)	(0.331)	(0.283)
	lnFDI	0.0041	−0.0582 **	−0.0541 *
		(0.010)	(0.027)	(0.030)
	lnER	−0.0125 **	−0.0068	−0.0193 *
		(0.006)	(0.011)	(0.011)
	lnIS	−0.0650	−0.0378	−0.1028
		(0.097)	(0.257)	(0.223)
Central Region	lnGBE	0.1629 ***	0.1902 **	0.3532 ***
		(0.032)	(0.090)	(0.093)
	lnFC	0.1525 ***	−0.0641	0.0884
		(0.014)	(0.068)	(0.070)
	lnHC	−0.0101	0.2935	0.2834
		(0.121)	(0.240)	(0.277)
	lnFDI	0.0517 ***	0.1146 **	0.1663 ***
		(0.009)	(0.047)	(0.054)
	lnER	0.0071	0.0243 **	0.0314 ***
		(0.005)	(0.010)	(0.011)
	lnIS	−0.4155 ***	−0.1687	−0.5842 **
		(0.048)	(0.203)	(0.235)
Western Region	lnGBE	0.1622 ***	0.4739 ***	0.6360 ***
		(0.055)	(0.124)	(0.148)
	lnFC	0.0365 **	−0.1769 ***	−0.1404 ***
		(0.016)	(0.045)	(0.049)
	lnHC	−0.1521	0.2284	0.0763
		(0.157)	(0.360)	(0.423)
	lnFDI	−0.0002	0.0314 ***	0.0312 **
		(0.005)	(0.011)	(0.013)
	lnER	0.0051	0.0126	0.0177
		(0.006)	(0.012)	(0.014)
	lnIS	−0.1319 *	−0.1429	−0.2747
		(0.069)	(0.184)	(0.226)

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

The provinces in the eastern region have a significant and positive impact on fixed capital (lnFC), both directly and indirectly. This indicates that fixed capital in these areas can significantly contribute to sustainable economic development. On the other hand, the central provinces can invest in other provinces while also promoting their own sustainable economic development. However, the western provinces mainly receive fixed capital from other provinces, which negatively impacts sustainable economic development. One possible explanation is that higher fixed investments use more natural resources.

Foreign direct investment (InFDI) has different effects on different regions of the country. In the eastern provinces, FDI has a negligible direct effect, while the indirect effect is significantly negative. This implies that the eastern provinces primarily invest in other provinces, which does not contribute to their sustainable economic development, but instead drains their resources. In contrast, the central provinces experience both significant and positive direct and indirect effects, indicating that they can significantly improve their sustainable economic development regardless of the source of the FDI. Finally, the western provinces welcome FDI from other regions, as it helps them to strengthen their economy and promote sustainable development.

Environmental regulations (InER) can have a direct impact on sustainable development, and it may not always be positive. When environmental regulations increase the costs of running a business, it can hinder the sustainable economic development of the eastern provinces. On the other hand, the central provinces' environmental regulations have a positive indirect effect, indicating that the current regulations in those regions can be maintained. Excessive environmental regulations can do more harm than good, and it is important to strike a balance between business interests and environmental concerns.

Results regarding industrial structure (lnIS) indicate that, even though the direct effects are considerably negative in the western and central provinces, the indirect effects do not hold much significance in the eastern provinces. This implies that despite making efforts to improve their industrial structure in comparison to other provinces, the western and central provinces are not contributing to the sustainable economic development of their own provinces. Additionally, neither the eastern nor the central provinces possess significant levels of human capital (lnHC).

5. Conclusions

5.1. Provincial and Municipal Business Environment Evaluation

This study applies principal component analysis (PCA) to assess the green business environments across different provinces and municipalities in mainland China, spanning from 2011 to 2020. The evaluation indices for the green business environment were proposed and referenced from other business environment evaluation indices published by various organizations. Furthermore, the regions of eastern, central, and western China are taken into account to categorize the provinces and municipalities, and their respective green business environments are analyzed.

According to the findings, the green business environment rankings place Guangdong, Shanghai, Jiangsu, Beijing, and Zhejiang in the top five, and Xinjiang, Guizhou, Ningxia, Gansu, and Qinghai at the bottom. Additionally, the eastern regions' provinces and municipalities exhibit superior performance in terms of the green business environment when compared to those in the central and western regions.

5.2. Effect of GBEEI on Sustainable Economic Development

The development of a green business environment holds great potential for fostering sustainable and high-quality economic growth. Moreover, such growth can extend beyond individual provinces and municipalities, benefiting neighboring regions as well. To investigate this phenomenon, the Spatial Dubin Model was employed to examine the spatial spillover effect of the green business environment on sustainable economic development across 30 provinces and municipalities between 2011 and 2020. Both economic and geographic distance weight matrices were utilized in the analysis.

According to the research, the green business environment has a significant impact on sustainable economic development in its region and neighboring areas. This dissertation also delves into the variations in the eastern, central, and western regions of China. While the eastern region solely relies on its own influence, the green business environments of both the region and its neighbors contribute to sustainable economic growth in the central and western regions.

5.3. Research Limitations and Future Research

In summary, the suggested index for evaluating the green business environment in mainland China is well-suited for the task at hand. Additionally, given its status as a central explanatory variable, the green business environment plays a significant role in promoting sustainable economic growth and corporate social responsibility, thus offering valuable insights for policymakers and businesses alike. Moving forward, there are several areas where this research can be further developed and expanded upon.

First, new indicators can still be considered for future research, even if the Green Business Environment Evaluation Index has been enhanced and supplemented in light of

earlier iterations. For instance, water pollution is one of the primary causes. Numerous studies have evaluated the emission of water pollution and its monitoring, control, eco-remediation, and potential environmental impact; among these is the remarkable study by Chen et al. that shows the impact of water pollution on ecosystem health and human health [24]. Our research's shortcoming, meanwhile, is the dearth of information on the emissions of water pollution. Since water contamination causes two million deaths a year, it has grown to be a severe worldwide problem that needs careful consideration.

Furthermore, the analysis of the study's spatial spillover impact involves incorporating both economic and geographic distance weight matrices. While these two weight matrices are commonly used, alternative weighting matrices can also be explored to validate the findings. Additionally, future research can adopt diverse methodologies to assess the economic distance between provinces and municipalities, such as examining their similarities, and can also incorporate geographical adjacency as a means of measuring distance.

In further research, we attempt to utilize the Fuzzy-set Qualitative Comparative Analysis (fsQCA) method, which has gained recognition for its objective and statistically informed approach to deriving predictive conclusions. This exemplifies a more asymmetrical way of thinking, in line with complexity theory [25]. The fsQCA methodology takes a comprehensive approach, considering both qualitative analysis and grouping perspectives. It regards the object of study as a collection of different combinations of condition variables and utilizes ensemble analysis to determine the collective relationships between groups and outcomes. This is particularly useful in tackling complex causal questions involving concurrent causality, causal symmetry, and scenario equivalence.

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Research on Green Development Decision Making of Logistics Enterprises Based on Three-Party Game

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Abstract: The concept of green logistics entails minimizing the ecological impact of logistical resources, enhancing the environmental quality within the logistics sector, and optimizing resource utilization to foster sustainable development in social economic production and consumption. Promoting green transportation is not only a positive reflection of the concepts of environmental protection and green development, but also an effective means for traditional logistics enterprises to reduce operating costs, win competitive advantages, and achieve transformation and upgrading. This paper takes logistics enterprises facing green transformation and development decisions as the research object, and puts forward an evolutionary game model between logistics companies, government, and community. The evolution path of logistics enterprises' green transformation development strategy choice under different conditions is analyzed in detail. The results show that, under the conditions of the government's incentive and supervision and the public's choice of green consumption, logistics enterprises are more inclined to green transformation development. Different levels of public choice and different levels of government regulation also make different corporate strategy choices. Therefore, it is suggested that the government provide policy, technical channels, funds, and other support for logistics companies promoting green logistics, and actively publicize the concept of green consumption in the market.

Keywords: three-party game; green logistics; decision

1. Introduction

Logistics is developing rapidly in today's world. The market of logistics enterprises expands with the increase in online consumption. However, the sharp increase in material flow has also increased the sharp increase in carbon dioxide emissions, which have a serious impact on the environment in each logistics link. The logistics industry is an industry with high carbon and high energy consumption, in which carbon emission is an important pollution source that needs to be treated. It is a difficult process to replace non-green logistics with green logistics for the government, logistics enterprises, and the market public, but it is also a general and necessary trend. However, green development is not only an effective measure to adapt to the development trend of the global logistics industry, but also core to the competitiveness of logistics companies. Green development is one way to reduce its operating costs in the future for logistics.

In recent years, the problem of the environment being affected by the development of logistics has become more acute and prominent. The green development of logistics companies can reduce the pollution caused by the flow of raw materials and resource consumption. According to the current science and technology, there is no way to completely eliminate the damage to the environment caused by logistics, that is to say, the impact on the environment is irreparable. Therefore, one of the management objectives of logistics enterprises is to limit or reduce the burden on the environment through a series of measures. Only in this way can the society achieve sustainable development.

The concept of green logistics first appeared in China around 2000. At that time, industry regulators also put forward higher requirements for green logistics management for the logistics industry, including the coordination and planning of storage, packaging, distribution, and other links, with saving logistics resources, protecting the environment and improving logistics efficiency as the basic goal. This was not only intended to achieve the enterprise's own goal of energy saving and efficiency, but it was also necessary to cooperate with the participation of the whole society to further build a green and low-carbon environment in the economy and society as a whole. In 2021, seven national agencies issued the "Program for promoting Green Ecological consumption", which aims to encourage the green development of logistics enterprises with an objective of achieving the goal of "green ecological distribution". In fact, in recent years, various ministries have issued a series of policy guidelines on "lighter" and "thinner" express delivery. In 2021, the "14th five-year Plan" for plastic pollution prevention and Control Action Plan was issued, which aims to achieve the environmental protection goal of express delivery of e-commerce and the express delivery industry by 2025, completely eliminating secondary packaging and increasing the use of recyclable express packaging to 10 million. In 2022, the "9917" project continued to make efforts to achieve the lessening, standardization, and sustainable development of express packaging so as to meet the needs of consumers and promote social and economic development. In the field of green logistics, including packaging, transport, storage, and distribution, manufacturers, suppliers, and the public need to take joint action and retrograde green logistics activities. Due to the promotion of the green development concept and green and low-carbon development policy, logistics enterprises are developing in the direction of modern logistics, which is in the pursuit of high efficiency and intends to pay more attention to reducing pollution, consumption, and emissions in China. All localities speed up the construction of intelligently designed green logistics parks, optimize system design, carry out cloud computing, and carry out appropriate recycling. Currently, the state's support for the logistics industry is increasing so as to help in the development of other industries in the country.

In recent years, the concept of green logistics continues to take root in the hearts of the people, and the green construction of logistics enterprises has gradually become the general trend of the development in industry. The implementation of green logistics measures of enterprises needs the promotion, support, and supervision of the government, and also needs to guide the market public to turn to the concept of green consumption.

Based on the previous studies, we know that the government and the public are two important influencing factors on whether logistics enterprises choose green development. However, scholars mostly discuss the relationship between the two from a unilateral perspective, and few study how the government and the public affect the choice of enterprises from the perspective of logistics enterprises. Therefore, this paper tries to put forward a game model between logistics enterprises, the government, and the market public as the main body and analyzes the strategic choice of each subject. It then puts forward some suggestions on the present situation of green logistics development for enterprises, government supervision policy, and green consumption behavior of the market public.

Our research makes three distinctive contributions within the existing field. Firstly, we consider several major aspects that affect logistics enterprises' choices of green development, which are the government's regulation and subsidy choices and public preference for green products and logistics enterprises' choices. Secondly, establishing the tripartite game relationship between the logistics enterprises, the government, and the public, this study examines the promotion process of dynamic equalization. Finally, according to the conclusion of our analysis, the paper gives some feasible suggestions for the green development of logistics enterprises

The subsequent structure of this article is arranged as follows. Section 2 reviews the theories related to the subject of this study. The problems to be investigated and the modeling assumptions are detailed in Section 3. Section 4 shows the game process and equilibrium analysis of the parties. In Section 5, based on the results discussed above, the development

strategy of logistics enterprises is proposed. Section 6 is the conclusion part, which summarizes the main conclusions of this paper and the action suggestions of all parties.

2. Theoretical Development

At present, many studies have shown that the power of government to promote the green development of enterprises cannot be underestimated. Fu Hongying (2022) studied and analyzed the development from the perspective of game theory for green logistics and found that government financial subsidies and the effective supervision mechanism were important driving forces for logistics enterprises to carry out green innovation [1]. Yu Lijing et al. (2018) pointed out that green innovation is an effective way for logistics enterprises to maintain a competitive advantage, and government participation in supervision is a booster of green innovation diffusion in logistics enterprises [2]. Chen and Zhang (2024) pointed out that, in order to cope with environmental challenges, the Chinese government encouraged enterprises to abide by corporate social responsibility, which made many enterprises gradually adopt cleaner production practices [3]. Han and Yang (2022) analyzed the interest game behavior between two typical target companies and a government, and found that the role of the government is embodied in guiding and motivating, such as guiding the alliance team to standardize the internal system and encouraging the restraint mechanism. The government also plays a crucial role in oversight, as enterprises may engage in collusion to deceive allowance and reward from government. This necessitates the establishment of robust mechanisms for monitoring systems, revealing information, and protecting intellectual property by both the government and relevant coalitions [4]. Cao et al. (2024) studied the effect of policies on green innovation and emphasized the mediating role of digitization, community responsibility, and treatment performance [5].

Regarding how to develop green logistics, Zhang Xiaolin et al. (2020), based on the perspective of green environmental protection, constructed a distribution route optimization model and solved it using the ant colony algorithm (ACA) by introducing factors such as fuel consumption and pollutant emissions into logistics distribution. It was proven that the optimization model was feasible and effective, as well as able to achieve the goal of shortest path and lowest pollutant discharge [6]. Fei Yin et al. (2022) expounded the role of circular economy in green logistics and gave reasonable policy suggestions to help build circular a green logistics system by introducing the operation mode of circular economy in the development of green logistics [7]. Yan Xiaoxia (2020) studied the logistics companies in China and optimized all the strategies for the government and logistics companies to encourage enterprises to reduce carbon emissions. According to the analysis, it was found that the comprehensive benefit of enterprises was obviously improved, and the cost was reduced after bringing low carbon into effect. The inspection strategy and meticulous comprehensive measures after the implementation of low-carbon subsidies by the government created a good environment for low-carbon development of enterprises [8]. Wang et al. (2021) put forward a freight price optimization model integrating market competition and carbon emissions of freight systems [9].

Regarding the impact of consumer choice on green development, Gizem Shou et al. (2023) studied how technological innovation in greenness affects the marketing sharing of logistics firms, and concluded that there is a role of relevant subjects and public concern [10]. Yang et al. (2023) pointed out that the green cooperation between logistics enterprises and the demand side can promote the sustainable consumption behavior of consumers and increase the trust in enterprises [11]. Zhang, Fang, and Wang (2020) analyzed the influence of customers in cold chain logistics enterprises on cold chain logistics service pricing, the pricing strategies under different conditions were given [12].

Concerning the factors influencing the implementation of green development in logistics, Cheng (2019) concluded that externalities and unimpeded information were the root causes of insufficient motivation for corporations to engage in green development [13]. Dong Yu et al. (2022), in order to study how various factors affect the implementation of

green logistics in enterprises, analyzed the evolutionary stability strategies of all parties in different situations. This showed that the participation willingness of the government, logistics corporations, and users had different effects on the evolution of the system [14]. Yu et al. (2019) found that the green technology innovation of logistics enterprises was affected not only by the intensity of government supervision, but also by the cost of green technology innovation and consumer behavior; government environmental protection publicity; and innovation incentives and pollution to logistics enterprises. The concept of green consumption can promote the green technology innovation of logistics enterprises [15]. Liang et al. (2020) found that environmental legislation and technical renovation can impact green development in the logistics industry [16]. Wu (2022) proposed a sustainable development strategy of green reverse logistics based on blockchain, used the structure of a Merkel tree to design a license chain to store detailed commodity traceability information, and stored the Merkel tree root node of the license chain block in the public chain [17]. Cheng, Han, and Ren (2023) analyzed panel data of 30 provinces during 2001–2019 using a generalized estimating equations regression model, and concluded that under the full sample, technological innovation, trade openness, and logistics infrastructure positively affected the green logistics development level, while government regulation and energy intensity negatively influenced the green logistics development level [18]. Tian et al. (2018) proposed a hybrid multi-criteria decision-making method combining the analytic hierarchy process and grey correlation technology to promote green development [19].

With regard to green logistics management and its importance, Li Xiaochen (2021) briefly introduced the significance of green logistics management, analyzed the problems existing in China's green logistics management in detail, and deeply analyzed its coping strategies [20]. Fu Junping (2022) pointed out that we must pay attention to the application of management methods in green logistics [21]. Taking urban joint distribution as an example, Zhang Ran (2021) introduced its distribution model, analyzed its green concept, revealed the importance of urban logistics greening, and made an in-depth analysis of its influencing factors to put forward some innovative suggestions to develop urban green logistics [22]. He Junze et al. (2022) pointed out that, in the process of logistics management, green management should be actively introduced to improve the effect of modern logistics management [23]. Wu Xuejin (2021) analyzed the current development of logistics management in China and a series of problems in the process of development, and put forward feasible methods for problems caused by the social development caused by the logistics industry in the process of development so as to promote the development of green logistics management in the future [24]. Wu Xie Mei (2021) expounded the research background of green logistics management, analyzed the current situation through PEST analysis, and put forward the corresponding management strategies for our country [25]. Wang et al. (2018) studied how the development of green logistics affects international trade. Through data analysis, it was found that the benefits of the former can promote the development of the latter [26].

To sum up, relevant scholars have studied and discussed the path and the influencing factors of green development of logistics enterprises. Green development is a necessary measure for logistics enterprises to reduce costs. Logistics enterprises can reduce environmental pollution by introducing low-carbon logistics equipment. A series of related behaviors such as government tax policies, laws, and regulations are the key factors for the development of green logistics [27,28]. By combing the relevant literature, we found that most scholars can reach a consensus: The role of government actions and consumer choice in the development of green logistics should not be underestimated. While the Chinese government is committed to promoting the advancement of eco-friendly logistics, conflicts of interest frequently arise among the three key stakeholders involved—namely, the government itself, logistics enterprises, and the market public. These conflicting interests often pose challenges in terms of achieving desired objectives. In practice, each of these participants tends to prioritize their own interests rather than aligning with one another. When it comes to green logistics development, the government's focus lies in

enhancing overall societal well-being; however, logistics enterprises and the market public have displayed limited enthusiasm due to their concerns for personal gains. Therefore, it is also common for logistics enterprises to give up the development of green logistics in order to pursue short-term interests. Based on this, coordinating the conflicts of interest of all parties can help to promote the development of green logistics in logistics enterprises. Therefore, from the perspective of game, this paper puts forward a tripartite game model of logistics companies, the government, and the market public; analyzes the interaction and key influencing factors of the strategic choices of all parties; and lays a theoretical foundation for logistics enterprises for green development.

3. Model Hypothesis and Construction and Its Evolutionary Equilibrium Analysis

3.1. Problem Description

Logistics enterprises choose green development according to their own needs. Profit maximization is the ultimate goal of every enterprise. As shown in Figure 1, the green development of logistics enterprises has certain economic externalities, and it is necessary to adopt vague measures to internalize the external benefits of green logistics development. The government uses some incentives and constraints to encourage enterprises to develop green logistics. These measures include tax breaks, subsidies, fines, and other policies. The development of logistics systems tends to become more and more sustainable. However, the distribution of interests is still a complex issue which involves multi-party participation. There will be a series of games. Therefore, the sustainable development of logistics depends not only on the power of the market, but also on the participation of the government. The Chinese government is taking a series of measures, including comprehensively implementing the green logistics policy, establishing a sound environmental protection system, increasing financial investments, encouraging and guiding enterprises to adopt advanced environmental protection technology, and implementing scientific environmental protection management. With the improvement of the public's concept of green consumption, green logistics has significantly improved the total utility of the public. Logistics corporations are committed to promoting green material flow, which is not only out of their own development needs, but also affected by the supervision of the government and the behavior choices of the public. The purpose of government supervision is to ensure the maximization of social benefits. Enterprises are concerned about whether they can obtain the maximum economic benefits, and the goal of the public is to pursue the overall interests of the individual.

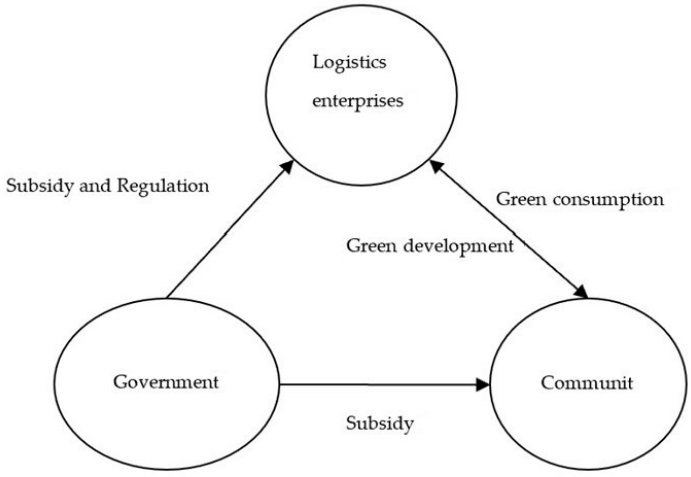

Figure 1. Relationships among the participants in green development decision making by logistics enterprises.

3.2. Basic Assumptions

The main body of the model includes logistics enterprises, the government, and the public, which follow the basic hypothesis of a bounded rationality evolution game. The

three utilize trial and error and choose through the game, and then change their own strategies so as to choose the optimal strategy to achieve equilibrium in the game. It is known that the strategy of logistics enterprises is green development or non-green development; the government's strategy is regulation or non-regulation; and the public's strategy is green consumption or non-green consumption. The probability that logistics companies choose green development is x, the probability that the government chooses to monitor is y, and z is the probability of the public choosing green consumption.

Hypothesis 1: The net income of logistics companies to choose green development is R_1, and the cost of capital, technology, manpower, and other resources invested in green logistics is C_1. If government supervises and the public chooses green consumption, the public demand for green logistics enterprises will increase the market share of logistics enterprises, and the increase in extra income is R_{11}. Under the condition that the government does not regulate and the public chooses green consumption, the increase in the extra income of enterprises is R_{12}. At this time, if the public does not choose green consumption, the extra income is 0.

Hypothesis 2: The behavior of the government is analyzed from two angles of subsidy and regulation cost. The government subsidizes W_1 to logistics enterprises that carry out green logistics development, and W_2 (logistics enterprises choose green development) and W_3 (logistics enterprises have no green development) to the public with a green consumption concept. Specific human and material resources require the government to invest in publicity and inspection, and the supervision cost is C_2. Green development increases social green benefits, and this is represented by an added value, R_2.

Hypothesis 3: There is a strong game relationship between the public green consumption concept and the green development of logistics companies. Therefore, it will guide the public to carry out green consumption for the process of green development for logistics companies. The utility of public non-green consumption is R_3, and public green consumption needs to pay costs C_3 (logistics enterprises choose green development) and C_4 (logistics enterprises choose non-green development). The public enjoys the logistics services brought by logistics companies, increasing the extra utility, and the utility increase is R_{31}.

3.3. Income Matrix of Tripartite Game

The return matrix for logistics enterprises, the government, and the public are presented in Table 1.

Table 1. Return matrix of tripartite game.

Logistics Enterprises	**Government**	**Public**	
		Green Consumption (z)	**Non-Green Consumption ($1-z$)**
Green development (x)	Subsidy and regulation (y)	$R_1 + R_{11} - C_1 + W_1$ $R_2 - W_1 - W_2 - C_2$ $R_3 + R_{31} - C_3 + W_2$	$R_1 + W_1 - C_1$ $R_2 - W_1 - C_2$ R_3
	No subsidy and regulation ($1-y$)	$R_1 + R_{12} - C_1$ R_2 $R_3 + R_{31} - C_3$	$R_1 - C_1$ R_2 R_3
Non-green development ($1-x$)	Subsidy and regulation (y)	$R_1 - C_1$ $-C_2 - W_3$ $R_3 + W_3 - C_4$	$R_1 - C_1$ $-C_2$ R_3
	No subsid7 and regulation ($1-y$)	$R_1 - C_1$ 0 $R_3 - C_4$	$R_1 - C_1$ 0 R_3

3.4. Construction of Replication Dynamic Equation

According to the income matrix, when a logistics enterprise chooses green development, the number equation of its expected return is:

$$E_{11} = yz(R_1 + R_{11} - C_1 + W_1) + y(R_1 - C_1 + W_1)(1 - z) + (1 - y)(R_1 + R_{12} - C_1)z + (1 - y)(R_1 - C_1)(1 - z) \quad (1)$$

When logistics enterprises choose non-green development, the expected return is:

$$E_{12} = yz(R_1 - C_1) + (1 - z)(R_1 - C_1)y + (1 - y)z(R_1 - C_1) + (1 - y)(R_1 - C_1)(1 - z) \quad (2)$$

The expected income of logistics enterprises is:

$$E_1 = E_{11}x + E_{12}(1 - x) \quad (3)$$

Thus, the replication dynamic equation for companies' green logistics development is:

$$\begin{aligned} F(x) &= \tfrac{dx}{dt} = x(E_{11} - E_1) \\ &= [R_{11}yz + W_1y + R_{12}(1 - y)z]x(1 - x) \end{aligned} \quad (4)$$

which can be known by the income matrix.

When the government implements a subsidy and regulation strategy, its expected return is:

$$E_{21} = xz(R_2 - W_1 - W_2 - C_2) + x(1 - z)(R_2 - W_1 - C_2) + (-C_2 - W_3)(1 - x)z + (-C_2)(1 - x)(1 - z) \quad (5)$$

When the government implements a non-subside and regulation strategy, its expected return is:

$$E_{22} = xzR_2 + R_2x(1 - z) \quad (6)$$

The expected income of the government is:

$$E_2 = E_{21}y + E_{22}(1 - y) \quad (7)$$

In the same way, the replication dynamic equation for a government with strict regulation is:

$$\begin{aligned} F(y) &= \tfrac{dy}{dt} = y(E_{21} - E_2) \\ &= [W_3xz - W_1x - W_3z - W_2xz - C_2]y(1 - y) \end{aligned} \quad (8)$$

In the same way, when the public is to carry out green consumption, its expected return is:

$$E_{31} = xy(R_3 + R_{31} + W_2 - C_3) + x(1 - y)(R_3 + R_{31} - C_3) + (1 - x)y(R_3 + W_3 - C_4) + (1 - x)(1 - y)(R_3 - C_4) \quad (9)$$

When the public chooses non-green consumption, its expected return is:

$$E_{32} = xyR_3 + xR_3(1 - y) + yR_3(1 - x) + (1 - y)R_3(1 - x) \quad (10)$$

The expected income of the enterprise is:

$$E_3 = E_{31}z + E_{32}(1 - z) \quad (11)$$

The dynamic equation of expectations for the public with green consumption is:

$$\begin{aligned} F(z) &= \tfrac{dz}{dt} = z(E_{31} - E_3) \\ &= [(W_2 - W_3)xy + (R_{31} - C_3 + C_4)x + W_3y - C_4]z(1 - z) \end{aligned} \quad (12)$$

Formulas (4), (8) and (12) constitute a dynamic replication system.

4. Equilibrium of Evolutionary Game and Its Asymptotic Stability Analysis

4.1. Asymptotic Stability Analysis

To solve the evolutionary game equation, let Equations (4), (8) and (12) be equal to zero. Eight special equilibrium points can be gained: there are P_1 (0,0,0), P_2 (1,0,0), P_3 (0,1,0), P_4 (0,0,1), P_5 (1,1,0), P_6 (1,0,1), P_7 (0,1,1), and P_8 (1,1,1). The stability of the above eight special equilibrium points is analyzed.

By calculating the partial derivatives of the independent variables of the Equations (4), (8) and (12), we can obtain the Jacobian matrix as follows:

$$J = \begin{bmatrix} \frac{dF(x)}{d(x)} & \frac{dF(x)}{d(y)} & \frac{dF(x)}{d(z)} \\ \frac{dF(y)}{d(x)} & \frac{dF(y)}{d(y)} & \frac{dF(y)}{d(z)} \\ \frac{dF(z)}{d(x)} & \frac{dF(z)}{d(y)} & \frac{dF(z)}{d(z)} \end{bmatrix} = \begin{bmatrix} J_{11} & J_{12} & J_{13} \\ J_{21} & J_{22} & J_{23} \\ J_{31} & J_{32} & J_{33} \end{bmatrix} \tag{13}$$

$$J_{11} = [(R_{11} - R_{12})yz + W_1 y + R_{12}z](1 - 2x) \tag{14}$$

$$J_{12} = [(R_{11} - R_{12})z + W_1]x(1 - x) \tag{15}$$

$$J_{13} = [(R_{11} - R_{12})y + R_{12}]x(1 - x) \tag{16}$$

$$J_{21} = [W_3 z - W_2 z - W_1]y(1 - y) \tag{17}$$

$$J_{22} = [W_3 xz - W_2 xz - W_1 x - W_3 z - C_2](1 - 2y) \tag{18}$$

$$J_{23} = [W_3 x - W_2 x - W_3]y(1 - y) \tag{19}$$

$$J_{31} = [(W_2 - W_3)\, y + R_{31} - C_3 + C_4]z(1 - z) \tag{20}$$

$$J_{32} = [(W_2 - W_3)x + W_3]z(1 - z) \tag{21}$$

$$J_{33} = [(W_2 - W_3)xy + (R_{31} - C_3 + C_4)x + W_3 y - C_4](1 - 2z) \tag{22}$$

Therefore, by substituting eight special points into Equation (13), the proper values of all special points can be calculated. Table 2 shows the proper values and stability conditions.

Table 2. Eigenvalues and stability conditions of equilibrium points.

Equilibrium Points	Eigenvalues			Signs of Eigenvalues	Stability
	λ1	λ2	λ3		
(0,0,0)	0	$-C_2$	$-C_4$	0; −; −	Critical equilibrium
(1,0,0)	0	$-W_1 - C_2$	$R_{31} - C_3$	0; −; uncertain	Conditional critical
(0,1,0)	C_2	W_1	$W_3 - C_4$	+; +; uncertain	Unstable
(0,0,1)	C_4	R_{12}	$-C_2 - W_3$	+; +; −	Unstable
(1,1,0)	$-W_1$	$C_2 + W_1$	$R_{31} - C_3 + W_2$	−; +; uncertain	Unstable
(1,0,1)	$C_3 - R_{31}$	$-R_{12}$	$-C_2 - W_1 - W_3$	uncertain;−; −	Conditional stable
(0,1,1)	$R_{11} + W_1$	$C_4 - W_3$	$C_2 + W_3$	+; uncertain;+	Unstable
(1,1,1)	$-R_{11} - W_1$	$C_3 - R_{31} - W_2$	$C_2 + W_1 + W_2$	−; uncertain; +	Unstable

Table 2 uses '0', '+', and '−' to represent eigenvalues, with the symbols 0, positive, negative, and 'uncertain' indicating that the symbol of the eigenvalue can be positive or negative under certain conditions. The stability of points is judged by the proper value

symbol of the matrix. If the proper value of a particular equilibrium point is negative, the point is locally asymptotically stable, and if there is at least one positive point, the point is unstable. The conditional stable point occurs with uncertain eigenvalues, and the conditional critical point occurs with uncertain eigenvalues and "0" eigenvalues.

Points P_3 (0,1,0), P_4 (0,0,1), P_5 (1,1,0), P_7 (0,1,1), and P_8 (1,1,1) all have at least one positive eigenvalue and are unstable points.

For point P_1 (0,0,0), two eigenvalues are negative and one is "0". P_1 (0,0,0) is asymptotically critical stable.

For point P_2 (1,0,0), the eigenvalues are negative or "0", and P_2 (1,0,0) is a conditional critical equilibrium point if $R_{31} < C_3$ is satisfied.

For the point P_6 (1,0,1), the corresponding eigenvalues are all negative if it satisfies $R_{31} < C_3$, and then P_6 (1,0,1) is a conditional stable point.

4.2. Stability Analysis of Enterprises

$F(x) = 0$ represents the dividing line of the steady state. According to Equation (4), when $(R_{11} - R_{12})yz + W_1y + R_{12}z = 0$, i.e., $y = y^* = -\frac{R_{11}z}{W_1+R_{11}z-R_{12}z}$, then $F(x) = = F'(x) == 0$, and it can reach a steady state. That is to say, when the probability y of the government choosing regulation and subsidies and the probability z of the public choosing green logistics products meet the condition $y = y^* = -\frac{R_{11}z}{W_1+R_{11}z-R_{12}z}$, the choice of logistics enterprises is stable. The proportion of logistics enterprises choosing whether to develop green logistics or not has no great impact on their income.

If $y > y^* = -\frac{R_{11}z}{W_1+R_{11}z-R_{12}z}$, when $F(x) = 0$, and $F'(x) < 0$, $x^* = 1$ is a steady state for the system of tripartite relations. That is to say, when logistics enterprises choose to develop green logistics, the system can reach a stable state.

If $y < y^* = -\frac{R_{11}z}{W_1+R_{11}z-R_{12}z}$, when $F(x) = 0$, and $F'(x) > 0$, $x^* = 0$ is a steady state for the system of tripartite relations. That is to say, when logistics enterprises do not choose to develop green logistics, the system can reach a stable state.

The dynamics trend of logistics enterprises is shown in Figure 2, where the overall feasible region is divided into two adjacent sections by the intersection space of y and z, which is marked in purple. The mixed strategy space of the logistics enterprises is produced as $\{x|x \in [0,1]\}$, and the arrows show the trend of x between $[0,1]$. That is, x converges to 0 when the feasible region is located in the lower plane region; then, it is optimal for logistics enterprises to develop non-green logistics. However, x converges to 1 when the feasible region is located in upper plane region; then, the optimal strategy is for logistics enterprises to develop green logistics.

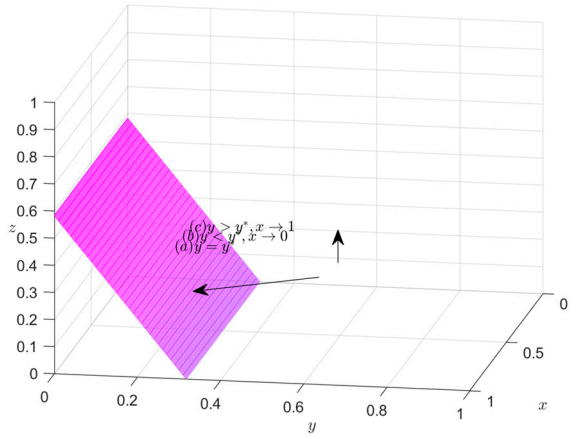

Figure 2. Dynamics trend schematic diagram of logistics enterprises.

4.3. Stability Analysis of Government

$F(y) = 0$ represents the dividing line of the steady state. According to the Formula (8), When $W_3xz - W_1x - W_3z - W_2xz - C_2 = 0$, i.e., $z = z^* = -\frac{C_2+W_1x}{W_3+W_2x-W_3x}$, then

$F(z) = = F'(z) == 0$, and it can reach a steady state. That is to say, the probability z of the public choosing green logistics products and the probability x of logistics enterprises to develop green logistics meet this condition: $z = z^* = -\frac{C_2+W_1x}{W_3+W_2x-W_3x}$. The proportion of the government to choose whether regulation and subsidies or not has no great impact on their income.

When $W_3xz - W_1x - W_3z - W_2xz - C_2 \neq 0$, if $F(y) = 0$, then $y^* = 0$, $y^* = 1$, which are a pair of stable points, are obtained.

If $z > -\frac{C_2+W_1x}{W_3+W_2x-W_3x}$, when $F(y) = 0$, and $F'(y) < 0$, $y^* = 1$ is a steady state for the system of tripartite relations. That is to say, regulation and subsidies are better options for governments to develop green logistics.

If $z < -\frac{C_2+W_1x}{W_3+W_2x-W_3x}$, when $F(y) = 0$, and $F'(y) > 0$, $y^* = 0$ is a steady state for the system of tripartite relations. That is to say, a lack of regulation and subsidies is a better option for governments.

The dynamics trend of the government is described in Figure 3, where the overall feasible region is divided into two adjacent sections by the intersection space of x and z, which is marked in pink. The mixed strategy space of the governments is produced as $\{y|y \in [0,1]\}$, and the arrows show the trend of y between $[0,1]$.That is, if y converges to 0 when the feasible region is located in the sub-plane region, then it is optimal for government to adopt non-regulation and non-subsidies. However, if y converges to 1 when the feasible region is located in the upper plane region, then the optimal strategy is for the government to choose regulation and subsidies.

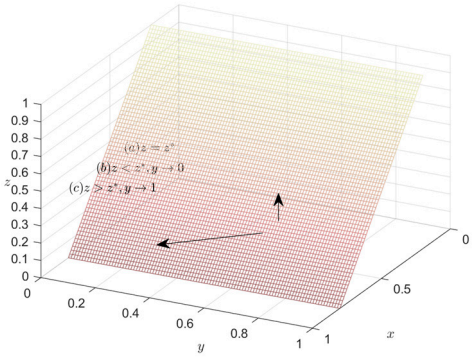

Figure 3. Dynamics trend schematic diagram of the government.

4.4. Stability Strategy of the Public

According to Formula (12), if $(W_2 - W_3)xy + (R_{31} - C_3+C_4)x + W_3y - C_4 = 0$, i.e., $x = x^* = \frac{C_4-W_3y}{C_4-C_3+R_{31}+W_2y-W_3y}$, then $F(z) = = F'(z) == 0$, it can reach a steady state. That is to say, when the probability x of logistics enterprises to develop green logistics and the probability y of the government choosing regulation and subsidies meet this condition, then $x = x^* = \frac{C_4-W_3y}{C_4-C_3+R_{31}+W_2y-W_3y}$. The proportion of the public choosing green logistics products or not has no great impact on their income.

When $(W_2 - W_3)xy + (R_{31} - C_3+C_4)x + W_3y - C_4 \neq 0$, if $F(z) = 0$, then $z^* = 0$, $z^* = 1$, which are a pair of stable points, are obtained.

If $x > \frac{C_4-W_3y}{C_4-C_3+R_{31}+W_2y-W_3y}$, when $F(z) = 0$, and $F'(z) < 0$, $z^* = 1$ is a steady state for the system of tripartite relations. That is to say, choosing green logistics products is a better option for the public.

If $x < \frac{C_4-W_3y}{C_4-C_3+R_{31}+W_2y-W_3y}$, when $F(z) = 0$, and $F'(z) > 0$, $z^* = 0$ is a steady state for the system of tripartite relations. That is to say, not choosing green products is a good decision for the public.

The dynamics trend of the public is described in Figure 4, where the overall feasible region is divided into two adjacent sections by the intersection space of x and y, which is marked in blue. The mixed strategy space of the public is produced as $\{z|z \in [0,1]\}$, and the arrows show the trend of z between $[0,1]$.That is, if z converges to 0 when the feasible

region is located in the left plane region, then it is optimal for the public to adopt non-green consumption. However, if z converges to 1 when the feasible region is located in right plane region, then the optimal strategy for the public is to choose green consumption.

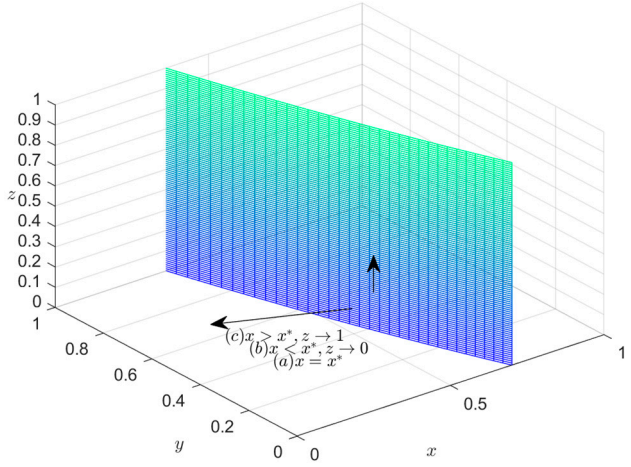

Figure 4. Dynamics trend schematic diagram of the public.

Through stability analysis, we found that there is a close relationship between the development status of logistics enterprises, the government's regulation and subsidies intensity y, and the public's green logistics preference intensity z; different national policies also bring different green development levels x of logistics corporations and green consumption levels z of the public; meanwhile, the public's green consumption is also affected by the level of green logistics and the intensity of government regulations and subsidies. By adjusting various parameters, we can achieve the best balance of the tripartite behavior and thus achieve the best game result.

5. Development Strategy Based on Equilibrium Analysis

Through the basic theory and method of an evolutionary game model, this paper analyzes how logistics corporations choose green development in a tripartite relationship. The following results are obtained: (1) Whether logistics companies choose green development is affected by public behavior, state support, and supervision. The more the public has a concept of green consumption, the greater the government's supervision and support for green logistics enterprises, and the more it can encourage logistics companies to develop green logistics. In order to implement green logistics, enterprises should not only consider the market, but also rely on the support of the government. Only by effectively guiding enterprises to participate in green logistics can the government better provide incentives for green logistics. Consumers' concepts of green consumption can impulse the technological innovation of logistics companies in green development. (2) Government supervision is mainly affected by profits and supervision costs. When the total benefit exceeds the cost of government regulation, the government will intervene in logistics enterprises to regulate. National supervision is the "thruster" of logistics enterprises' green development. The government plays a crucial role in oversight. The green development of logistics enterprises is affected by the intensity of government supervision, environmental protection publicity, and innovation incentives of the government, as well as pollution fines and taxes on logistics enterprises. (3) The lower the cost of green development, the more logistics enterprises tend to pursue green development. Therefore, as there are more green subsidies to these enterprises, along with subsidies to the public and more government investment in the implementation of green logistics enterprises, the green development of enterprises and the formation of a public green consumption concept will be promoted. The more we promote the formation of green concept, the more we can promote the development of green logistics enterprises.

To sum up, logistics companies that want to achieve green development can:

(1) Establish a green information disclosure system. In accordance with the requirements of environmental audit, they can regularly issue sustainable development reports and corporate social responsibility reports and encourage enterprises to strengthen their environmental responsibility.
(2) Strengthen the research, development, and application of green technology innovation. If we want to protect the environment more effectively, we need to take measures to make technology more environmentally friendly. First of all, we need to strengthen the management of renewable packaging, formulate relevant environmental protection policies, and promote environmentally friendly packaging. Secondly, we also need to take measures to save resources, such as using clean fuel, controlling energy consumption, and reducing environmental pollution. Finally, we also need to carry out scientific warehouse management in order to improve environmental protection. In a word, we need to take measures to promote environmental protection and social progress. The use of big data, IoT, artificial intelligence, and accurate orientation technology greatly enhance the efficiency of logistics, thus greatly promoting logistics corporations to a higher level of progress.
(3) Encourage cooperation and exchanges and promote the transformation of the industry. Encourage industry, university, and research to jointly build an innovation platform, encourage mutual cooperation among enterprises, establish a green postal and express service alliance, promote the green development experience of the industry in multiple levels and multiple channels, and promote the promotion of the concept of green logistics.

Companies can improve resource deployment and reduce the burden of transportation. They can accomplish this by vigorously pushing forward the development of "end-to-end" and "door-to-door" logistics models; vigorously developing third-party suppliers; promoting the simplification of logistics distribution; promoting the utilization of renewable resources; reasonably configuring and planning transport routes and transport channels; reducing vehicle congestion; actively promoting the construction of logistics supply chain information platforms; and further strengthening the overall operation of logistics components.

6. Conclusions

From the findings of this paper, we can obtain some enlightenment regarding the green development of logistics enterprises: (1) Although logistics enterprises have carried out a series of green development initiatives, they still need the government to adopt different ways and methods to promote this modernization process. The government should support the green innovation of logistics companies, strengthen regulatory measures, and reduce regulatory expenditure so as to avoid wastes of resources caused by wasteful expenditure. (2) The impact of mass consumption on green logistics cannot be ignored. If the public does not have green consumption, the government should increase public subsidies and increase public demand for green consumption, which will further stimulate logistics companies to invest in green development. (3) Logistics companies need to be environmentally conscious so that they can invest more money in innovation research for green development, reduce pollution, and reduce resource consumption. The public must understand the concept of green consumption, which can consume green products and promote the demand for and development of logistics companies.

Green logistics will bring about the coordinated development of economic benefits, environmental benefits, and social benefits. Based on this characteristic, logistics enterprises should actively invest in cooperation with the government and gradually promote the improvement of the standardized service system of green logistics through the co-construction of government and enterprises, which can not only effectively enhance the entry threshold of the green logistics industry, but also help to eliminate backward production capacity and solve the restrictive impact of traditional logistics on the development of green. It reflects the advantages of the development of green logistics enterprises.

At present, with the in-depth application of green business models, not only will logistics enterprises achieve their own sustainable and high-quality development, but the green development of the industry will also be accelerated. To this end, logistics enterprises should continue trying to achieve comprehensive coverage of green logistics. In order to realize the modern management and development of green logistics, we must strengthen the green logistics awareness of enterprises, managers, employees, and consumers, and establish a comprehensive management and supervision mechanism through publicity activities using various channels. In order to obtain the double return of economy and society, and to encourage all parties to participate in it, enterprises should make full use of their influence to provide positive examples for employees, customers, and suppliers to accelerate the greenization of logistic., This will create a win–win situation for the economy, society, and environment, and contribute to the sustainable development of the country.

Enterprises should actively promote the concept of green logistics so as to realize the long-term development of enterprises and society, and advocate for a team spirit of unity, cooperation, and environmental friendliness. Saving manpower, reducing waste, and preventing pollution are the long-term strategic goals of enterprise development. The government should issue policies and regulations to push forward green logistics, speed up the construction of green logistics infrastructure, and enhance the support of basic economic education facilities so as to push forward the sustainable development of green companies. The government should take some measures, such as encouraging the application of innovation and technology, strengthening the transformation of existing infrastructure, expanding its scale, optimizing its layout, realizing the integration of science and culture, improving the management efficiency of facilities, and maximizing its comprehensive economic benefits.

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Two-Way Causality Between Economic Growth and Environmental Quality: Scale in the New Capital of Indonesia

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Abstract: The world is still facing an old challenge, e.g., environmental change. In many nations, including developing countries such as Indonesia, spurring economic growth is considered the best way to overcome many things. Indonesia is moving the center of the Indonesian Capital City (IKN). By opening up new space through the consideration of equitable economic development toward a green environment, this study is designed to investigate the impact of economic growth on environmental quality and vice versa. The object of analysis is directed at Penajam Paser Utara (PPU) as the new *IKN* center and four other *IKN* buffer areas in East Kalimantan, including (1) Paser, (2) Balikpapan, (3) Samarinda, and (4) Kutai Kartanegara. This study uses panel data regression and linear trends. The data elaborated is economic growth based on Regional Domestic Product (GRDP), which is proxied, and environmental quality, as reflected by the Environmental Quality Index (IKLH), during the 2017–2023 period. Referring to the method implemented, there is significant positive causality between the two in the selected *IKN* areas. Through the linear trend model, it is found that there is a tendency for changes in the data analyzed based on constant time. This study can be an instrument for practical policy making and a breakthrough in the development of a scientific discipline that studies the relationship between economic growth and environmental quality in two directions.

Keywords: economic growth; environmental quality; panel data regression; linear trend; IKN

1. Introduction

One of the signals for assessing success in economic development is economic growth [1]. As is known, economic growth is seen by many countries as a measure of government performance in driving prosperity [2]. However, because natural resources are becoming increasingly depleted, attention to the intensity of economic growth also requires the consideration of environmental sustainability. Environmental sustainability is seen as a universal topic that is always interesting to highlight. Inclusive economic growth is a spillover effect of comprehensive environmental governance [3,4]. As an illustration, the majority of developed countries save resources by employing appropriate technology to realize a green economy. This policy is the main attribute in reducing environmental damage. On the one hand, poor and developing countries that rely on nature are actually more expansive in exploiting nature to realize economic growth. Inefficient management

causes contradictions in the resources exploration framework according to basic sectors in each region.

Holistically, the relevance of economic growth to environmental sustainability has been widely discussed in several past publications. As an illustration, research from Yang et al. [5] reveals the connection between economic growth and environmental protection in China. With decoupling terminology, it is found that there is a strong correlation between economic growth and the environment, so the environmental pressure at regional and domestic levels is decreasing. The paper written by Alam and Kabir [6] investigates the interaction between Gross Domestic Product (GDP) per capita and environmental sustainability in Southeast Asia and East Asia. In parallel, increasing GDP per capita has implications for pollution efforts, but there are mixed results (negative or positive) for eco-efficiency efforts. The hypothesis in the Kuznets Curve has been partially proven to have a partial impact on the environment, although not comprehensively. Anwarya [7] highlighted the connection between economic development and ecological sustainability. This paper centers on the role of environmental protection spending in bridging the effects of GDP per capita on carbon emissions per capita in several countries selected for identification. First, GDP per capita significantly influences carbon emissions per capita. Second, spending on environmental protection moderates the significant relationship between GDP per capita and carbon emissions per capita. Then, Obiora et al. [8] explained that increasing economic growth causes environmental sustainability in developing markets to be threatened. In this case, the mitigation of carbon emissions at all levels increases due to the position of domestic credit in the private sector, such as (1) the combustion, (2) buildings, (3) transportation, and (4) electricity industries, which are increasingly developing. Cumming and von Cramon-Taubadel [9] stated that the effect between economic growth and environmental sustainability is negative, where global ecological degradation triggers changes in income and population growth that are increasingly far from sustainable. In the context of the international and national economy, economic growth that is not balanced with a prime ecosystem balance will result in a resource crisis that will actually have a negative impact on environmental sustainability.

The government has been relocating the capital of Indonesia since 2024. Under the regulations contained in Law Number: 3 of 2022, the relocation of the Indonesian Capital City (IKN) from Jakarta to East Kalimantan is a fundamental urgency. Apart from solving social problems, economic and environmental aspects are crucial considerations in relocating IKN. Examples are environmental and economic sustainability. The environment is the first factor behind the move, as Java Island is known as the area with the highest population density in Indonesia, along with high environmental degradation, compared to other islands. A bad environment creates less than optimal access to health. The second factor is economic. The population density in Java also triggers economic competition, especially competition in labor-intensive fields. Even though the government's budget for development spending on the island of Java is relatively more dominant than in other regions, the tight competition for human resources has made it difficult for the majority of unskilled workers to find employment opportunities based on adequate wage standards. Only skilled workers with skills that match the company's wishes have the opportunity to occupy professional positions. On the basis of the above, the environmental and economic objectives of the *IKN* project are expected to overcome the clean water crisis, reduce environmental pollution by switching to clean energy, equalize infrastructure gaps, end poverty and unemployment, provide jobs, attract investment to open decent housing, and support widespread improvement in welfare [10–13].

Figure 1 is a map of the distance of the movement of Indonesian *IKN* from Jakarta to the East Kalimantan region. In its progress, *IKN* began by building a central government

building. Other development mechanisms, such as supporting facilities, are being implemented in stages. The initial transfer process for *IKN* also coincides with the celebration of the proclamation of independence for the Republic of Indonesia on 17 August 2024. Administratively, the area used as the center of *IKN* is Sepaku District, which is located in Penajaman Paser Utara (PPU). The transfer distance from Jakarta to *IKN* is ± 1300 km, and, considering the population explosion factor in the old capital reaching around 11 million people, it is necessary to move to areas with low populations, such as *IKN*, which has 170 thousand people. With so many foundations for relocating *IKN* and, at the same time, seeing the obstacles from global polemics, such as the economy and the environment, which absolutely need to be highlighted, it is necessary to sharpen the analysis.

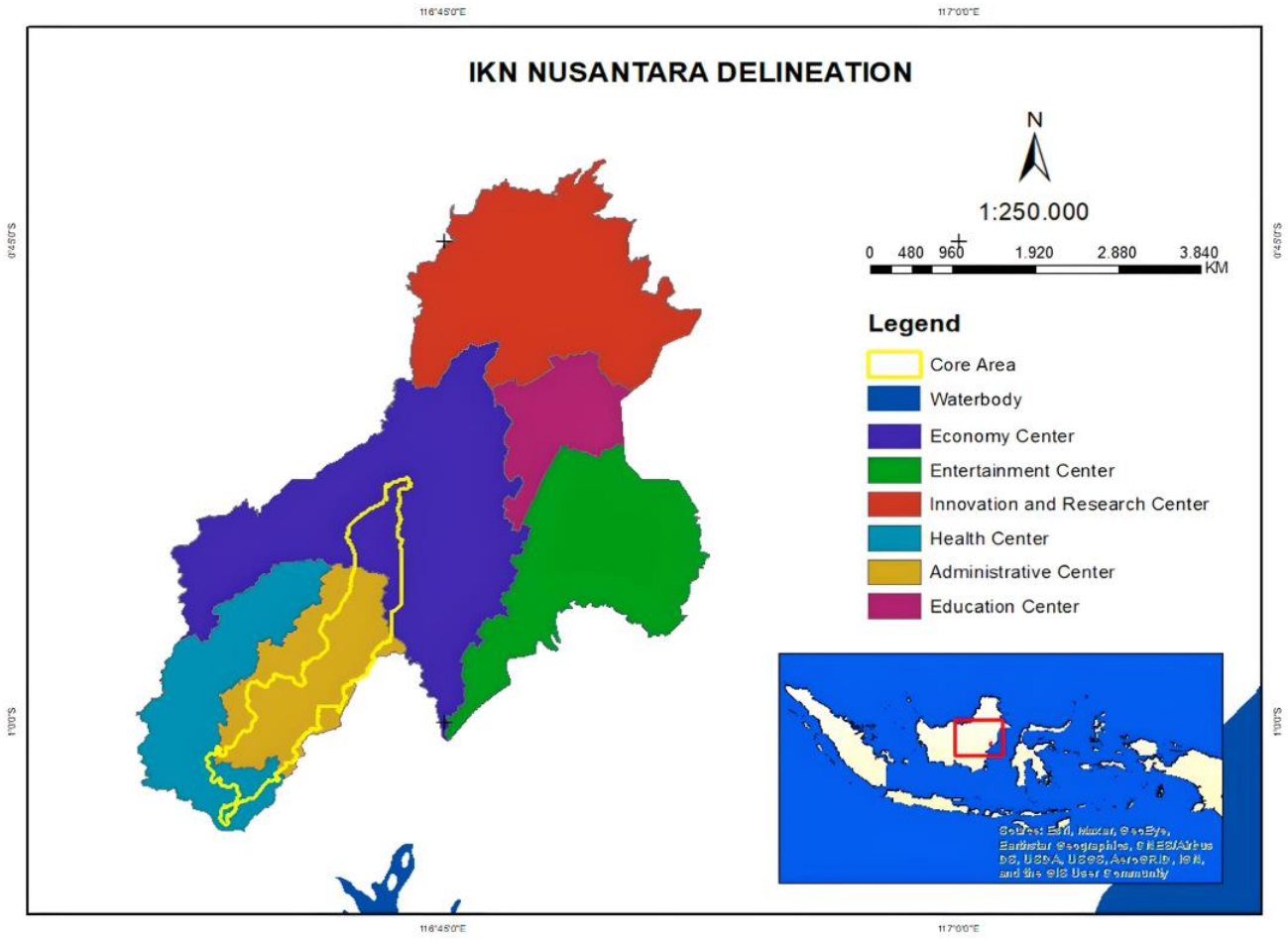

Figure 1. Map IKN based on clusters. Source: Syaban and Appiah-Opoku [14].

The key to successful economic and environmental development in *IKN* is how to realize impressive economic growth with population productivity and the correct use of resources. Rosyadi et al. [15] estimated that the future needs of residents in the *IKN* area for electricity and water consumption will increase rapidly. At the same time, the current reality shows that energy-generating units such as gas, water, and electricity in the *IKN* zone are increasing in line with high demand. It is feared that the growing energy production capacity will actually have a drastic impact on climate change [16].

The usefulness of the proposed study is to predict the link between economic growth and environmental quality in two directions in the *IKN* center and *IKN* buffer areas during the 2017–2023 period. The aim of this study was to build academic ideas and become the foundation for professional decision making through two dynamic premises between economic growth and environmental quality and vice versa. The scope of the proposed

activities focuses on five regions, where the *IKN* centers are PPU, Paser, Balikpapan, Samarinda, and Kutai Kartanegara. Meanwhile, the identification period is 2017–2023.

In previous editions, there is a positive reaction from economic growth to the environment [17–26]. It was also found that there was an inverse relationship between the environment and economic growth in a negative direction. Malaysia, the Republic of Korea, and Kazakhstan are valuable lessons that are relevant. Contextually, the development of new capital cities in three countries in Asia is motivated by economic and environmental principles through adequate actions. These three countries in Asia are valuable lessons that are relevant. Malaysia, the Republic of Korea, and Kazakhstan are regions with outstanding natural resources but have development disparities. A modern new capital involves rigor in planning, infrastructure investment, and governance. This development model transforms better in rebalancing the economy and reducing environmental damage [27]. Although studies linking the relationship between economic growth and environmental quality and environmental quality to economic growth are not new, studies with samples in *IKN* have never been carried out. In this way, the originality of this study through the modification of different objects provides an opportunity to generate new ideas to be developed in the next agenda.

2. Literature Review

2.1. Sustainable Development

Sustainable development speaks of a development process that emphasizes meeting current needs without sacrificing meeting the needs of future generations, including the environment [28]. Sustainable development must ensure the use and preservation of the environment so that environmental quality is maintained [29,30]. Langhelle [31] explains that development can be said to be sustainable if social justice has been realized across generations. Viewed from a more specific segment, sustainable development is a global design to preserve ecosystem functions and capabilities [32]. Implicitly, practices in sustainable development also cover society, business, urban/rural areas, and land by minimizing the impacts caused by human routines.

Figure 2 illustrates three clusters in sustainable development, including (1) the social cluster, (2) economic cluster, and (3) environmental cluster. Social clusters rely on guarantees of social services, social justice, and wealth distribution. Economic clusters initiate stable economic growth by restructuring production techniques to save resources, especially energy. The environmental cluster is tasked with maintaining the comfort and safety of the living environment. The four pillars of sustainable development include (1) a long-term perspective, (2) an integrative approach, (3) respect for diversity, and (4) equity and social justice. First, a long-term perspective involves planning the efficient use and management of resources. Second, an integrative approach involves development that is guided by the reciprocal relationship between humans and the environment. Third, respecting diversity is oriented toward preventing discriminatory behavior toward cultural diversity and maintaining biodiversity. Fourth, equality and social justice are carried out to ensure that there is no inequality of resources in the present and future, for example, gender equality and the equal distribution of land.

Figure 2. The relationship between economic, social, and environmental factors in sustainable development. Source: Waaswa and Satognon [33].

For conditions like Indonesia, sustainable development is concentrated on four factors: (1) tourism resources, (2) marine resources, (3) mining resources, and (4) forestry resources. These four factors are considered to have vital consequences and can influence the continuation of sustainable development because the resource potential and dependence on economic livelihoods are quite dominant compared to other sectors. The sustainable development of tourism resources prioritizes environmental balance in tourist attractions, expanding employment opportunities, revitalizing regional development that supports economic activities, optimizing the country's foreign exchange and the volume of foreign tourist visits, and fostering a sense of love for the surrounding environment. The sustainable development of marine resources involves fishing methods with nets or other types of environmentally friendly fishing gear, prohibiting the use of chemical poisons, explosives, etc., to catch fish, selecting fish targets to reduce the possibility of catching protected fish, observation and supervision of endangered fish, and conserving coral rocks and mangrove forests. The sustainable development of mining resources prioritizes replanting deforested forests, prohibits deforestation, implements a selective logging system, tightens regulations through logging for every forest felling, and enforces heavy sanctions for those who violate forest management [34].

2.2. Economic Growth

Economic growth is articulated as an increase in output per capita in the long term [35,36]. This means that there is an increase in the accumulation of residents' income in a country or region in a certain period [37]. As explained at the beginning, economic growth is a symbol of a nation's prosperity. From a macro perspective, there are three trends in economic conditions, i.e., negative trends, stagnant trends, and positive trends [38]. If the economic growth trend is negative (minus), then an area is affected by a recession, or a welfare contraction occurs. Meanwhile, the trend of stagnant economic growth (less than 3%) per year indicates that a region is experiencing a slowdown in national consumption and production. The positive economic growth trend (more than 3%) actually detects that there is a significant increase in household and domestic income and expenditure.

On a national scale, economic growth is calculated based on Gross Domestic Product (GDP), while on a regional scale, economic growth is calculated using Gross Regional Domestic Product (GRDP). Both GDP and GRDP are calculated using three factors,

i.e., production, income, and expenditure. These three factors also produce the same numbers in projecting the rate of economic growth. Generally, GDP and GRDP data are displayed based on two components: (1) current prices/ADHB and (2) constant prices/ADHK. ADHB economic growth reflects the final added value of services and goods according to the prices prevailing per period. Economic growth in this category is also a basis for viewing economic structure and shifts. ADHK economic growth functions to diagnose the economy from period to period according to the added value of services and goods seen from the prices prevailing in a particular period as a basis. The economic growth indicator is a percentage (%), while GRDP and GDP refer to nominal units (Rupiah/IDR).

In Indonesia, economic growth is divided into the following seventeen sectors: (1) agriculture, forestry, and fisheries; (2) mining and quarrying; (3) processing industry; (4) procurement of electricity and gas; (5) water supply, waste management, waste, and recycling; (6) construction; (7) wholesale and retail trade, repair, and maintenance of cars and motorbikes; (8) transportation and warehousing; (9) provision of accommodation and food and drink; (10) information and communication; (11) financial and insurance services; (12) real estate; (13) company services; (14) government administration, defense, and mandatory social security; (15) educational services; (16) health services and social activities; and (17) other services. Below is the formulation of economic growth in the form of national income:

$$GNP = C + I + G + (X - M) + T \quad (1)$$

where *GNP* (Gross National Product), *C* (Household consumption), *I* (Investment), *G* (Government consumption), *X* (Export), *M* (Import), and *T* (Tax).

2.3. Environmental Preservation

The meanings of conservation and environment are often used interchangeably in the corridors of environmental management, but these two words are very different. Conservation is interpreted as a solution to protect the environment through the responsible use of natural resources, while preservation is the protection of the environment from dangerous human activities. For example, forest conservation usually involves environmentally friendly logging procedures to minimize deforestation. In this phase, conservation will set aside part or even all of the forest to protect it from development activities.

Issues related to climate change related to human and environmental interactions are currently being highlighted. A growing number of studies are strengthening the understanding of what can be carried out to stimulate and reverse the effects of extreme environmental conditions through individual awareness. In psychology, there is a limited synthesis of what drives pro-environmental behavior, from various stigmas to concrete actions. Correspondingly, Kothe et al. [39] revealed that most research focuses on applying protection motivation theory through systematic mapping to simulate and change pro-environmental behavior.

One of the initial indications to describe the environmental situation at a regional level in a certain period is the Environmental Quality Index (IKLH). The *IKLH* is an element of environmental management in Indonesia that combines the Environmental Performance Index (EPI) and the concept of environmental sustainability. The *IKLH* can describe and evaluate the performance of environmental improvement programs. Apart from that, as information material in the policy making process related to environmental management and protection. The *IKLH* score and the three composites in the *IKLH* are grouped into the following six statuses: (1) Alert if $30 \leq IKLH > 40$; (2) Very poor if $40 \leq IKLH > 50$; (3) Not good if $50 \leq IKLH > 60$; (4) Moderate if $60 \leq IKLH > 70$; (5) Good if $70 \leq IKLH > 80$;

and (6) Superior if *IKLH* > 80. The formula for the *IKLH* on a regional and national scale is written as follows:

$$IKLH_{reg} = (40\% \times IKTL) + (30\% \times IKU) + (30\% \times IKA) \quad (2)$$

$$IKLH_{Nas} = \sum_{i=1}^{38} Reg_i \times \left\{ \frac{\left(\frac{Pop_{nas_i} + TA_{nas_i}}{Pop_{prov} + TA_{prov}} \right)}{2} \right\} \quad (3)$$

where *IKLH* (Environmental Quality Index), *Reg* (Regional), *Prov* (Province), *IKTL* (Land Cover Quality Index), *IKU* (Air Quality Index), *IKA* (Water Quality Index), *Nas* (National), *Pop* (Population), and *TA* (Total Area).

2.4. Conceptual Development

One theory that deepens the relationship between economic growth and the environment is that up to a certain point, GDP will worsen the environment. Yet, after moving to a post-industrial revolution economy, it seemed to increasingly lead to a decline in environmental quality [40]. Furthermore, since the 1980s, the US and UK have been able to reduce CO_2 emissions. In general, growth in global emissions actually comes from developing countries [41,42]. For example, in China, industry and coal are the biggest driving sources in changing the characteristics of domestic CO_2 emissions, reaching 79.83%. Multi-stage energy intensity is able to mitigate excessive energy consumption toward low carbon emissions [43]. In other cases, when economic growth is emphasized, it results in pollution from wood and coal commodities. Interestingly, with higher incomes, economies can navigate cleaner technologies to limit pollution. Arrow et al. [44], who researched economic growth and carrying capacity, observed different spaces in the "U"-shaped curve, where the environmental costs of economic activities triggered an overlap. The findings confirm that environmental costs are borne by other countries, future generations, and poor people. Incentive funds cannot solve the constraint.

The conflict between economic growth and the environment today is sharper than in previous eras. Indeed, the relationship between economic growth and ecosystem sustainability has been reviewed in much of the literature, but the results remain controversial. This experience brings together a broad perspective to integrate economic growth and environmental degradation into specific references in highlighting the polemics of deforestation and carbon emissions. A simple identification is based on the Environmental Kuznets Curve (EKC), which places an "inverted U" pattern in the relationship between per capita income and environmental quality. Specifically, the analysis is useful for determining the impact of progressive world economic integration on the relationship between economic growth and environmental degradation. Hasid et al. [45] showed an inverse relationship between income growth and carbon emissions. However, this evidence does not apply to the context of forest change. On the other hand, the direct relationship between increasing the degree of integration in the global economy can trigger environmental degradation.

Basically, the environment also depends on economic growth. Apart from the effect of economic growth on the environment, there is a synergy between the environment and economic growth, as illustrated by several studies that discuss the relationship of the environment to the sustainability of economic growth [46–51]. Today, the world's view of environmental sustainability and economic development has shifted. From what was initially conservative, it is now transitioning to a more transformative path. Environmental sustainability and economic development have been correlated with each other. In fact, the majority of economically developed countries are aware of environmental sustainability issues. By grouping countries based on developing and advanced economic predicates,

it can be seen that developing countries with natural resource prospects that are more dominant than developed countries have a negative environmental sustainability cycle. Meanwhile, the application of two hypotheses, e.g., the Kuznets Curve and Maslow's Hierarchy of Needs for case studies in developed countries, can be accepted in channeling the principles of environmental sustainability into economic development. Wise management of resources can automatically reduce environmental degradation to create sustainable economic development in Pakistan. Through a friendly environment, economic growth will run harmoniously to direct intelligent steps in controlling the use of the earth's limited resources. By limiting responsible environmental exploitation, it is possible to achieve productivity in economic systems and activities.

Environmental sustainability cannot be separated from economic growth. As an illustration, there are nine countries in Eastern Europe where the validity of the decoupling hypothesis shows an asymmetric pattern between environmental sustainability and economic growth. In addition, there is a strong cointegration of environmental benefits and economic growth in the long term, but, in the short term, economic growth causes environmental degradation due to the use of fossil fuels, thus creating dirty industries. From a different scope, sustainable development triggers controversy that invites debate. Does it boost economic growth, or does it start from protecting the environment? Opponents of environmental protection assume it should not come at the expense of individual freedoms and rights, including economic growth. In contrast, environmental protection advocates are concerned with limiting global resources for future generations, even at the expense of economic growth. Most individual freedoms in eleven post-Soviet countries are predicted to have a high level of preference for protecting economic growth and the environment. Concern for environmental sustainability has been demonstrated by several areas in China through which the Yangtze River flows by creating massive pollutant emission reduction schemes that must be followed by companies operating in the industrial sector. One form of this commitment is reducing wastewater and carbon emissions per unit of industrial output to produce mutually beneficial environmental and economic resilience.

The dynamics between economic growth and environmental quality have been widely discussed in various scientific papers, where there is a two-way causality between the two [52–57]. Economic growth replicates increases in real output (GDP). Therefore, with increasing accumulation and consumption, there tends to be a burden on the environment. The environmental impact of economic growth is responded to by increased consumption of non-renewable resources, global warming, excessive levels of pollution, and the potential loss of environmental habitats. However, it is understood that not all economic growth causes environmental damage. As real incomes increase, residents have a greater ability to devote resources dedicated to stopping the harmful effects of pollution and protecting the environment. Rapid technology-driven economic growth can offer more efficient output with lower levels of pollution. Based on the theoretical arguments and empirical studies above, the framework for existing research was developed as follows:

Through Figure 3, two hypothetical expectations that can be proposed are explained as follows:

H1. *Economic growth can affect environmental quality.*

H2. *Environmental quality can affect economic growth.*

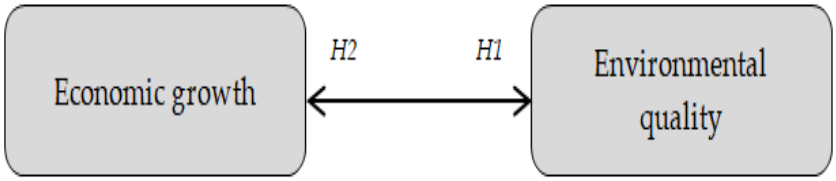

Figure 3. Framework.

3. Methodology

3.1. Sample Data

The data material is secondary. The data were collected from government agencies authorized to provide data. Data about economic reports are selected from various series. Data objectivity concerns economic growth and environmental quality. The study sample focuses on five regions in East Kalimantan, including (1) Paser, (2) PPU, (3) Balikpapan, (4) Samarinda, and (5) Kutai Kartanegara. This place was chosen because it is important in supporting *IKN* development. Prawitasari et al. [58] argue that there is a vital partnership between PPU, which is a relocation zone, and the surrounding area, where Paser plays its role as a residential area, Balikpapan is a logistics and transportation center, Samarinda is a cultural and historical development area, and Kutai Kartanegara is a peripheral area to supply local food needs. Thus, this is a logical reason for many groups to highlight the role of the five locations above.

The data entities used in this study are economic growth and the environment. The intended economic growth is based on constant GRDP data (percent), while environmental quality is based on *IKLH* data (index). Tables 1 and 2 describe the data observed over a period of seven periods. Substantively, the average economic growth data in both *IKN* and the four regions around *IKN* is positive throughout 2017–2019 and 2021–2023. Even in four regions, namely Paser, Balikpapan, Samarinda, and Kutai Kartanegara, the average economic growth is above the national level. In PPU, the average economic growth is actually below the national level. PPU's negative economic growth performance is an accumulation of the COVID-19 pandemic in 2020. In particular, environmental quality data represents varying scores in the *IKN* and four buffer areas during 2017–2023. Uniquely, environmental data in 2021 show that for all areas, it is light green, but the status is good. The average score for environmental quality in Indonesia is 73.16 points in the good category. Even though they are both classified as good, the environmental quality at PPU (77.79 points), Balikpapan (73.83 points), and Kutai Kartanegara (79.53 points) is above the national level. In comparison, the environmental quality in Paser (68.82 points) and Samarinda (68.78 points) is actually below the national average or moderate.

Table 1. Economic growth in PPU, Paser, Balikpapan, Samarinda, and Kutai Kartanegara.

Region	2017	2018	2019	2020	2021	2022	2023
PPU	3.13	2.64	4.7	−2.9	2.55	4.48	6.22
Paser	5.17	5.07	5.09	−1.82	4.8	5.07	4.46
Balikpapan	6.73	5.61	6.12	−1.41	3.59	6.45	4.14
Samarinda	5.28	5.08	4.09	1.82	3.48	5.11	4.84
Kutai Kartanegara	6.8	5.36	6.89	−1.09	3.99	5.32	4.94
Indonesia	5.07	5.17	5.02	−2.07	3.7	5.31	5.05

Source: Central Statistics Agency-East Kalimantan [59].

Table 2. *IKLH* in PPU, Paser, Balikpapan, Samarinda, and Kutai Kartanegara.

Region	2017	2018	2019	2020	2021	2022	2023
PPU	75.65	85.9	80.87	76.45	75.06	74.46	76.15
Paser	74.17	73.09	65.92	70.07	73.22	62.39	62.9
Balikpapan	71.47	75.71	74.2	72.74	75.29	73.97	73.41
Samarinda	69.38	68.78	61.94	68.43	71.03	68.43	73.5
Kutai Kartanegara	81.87	86.88	78.98	78.49	75.06	74.46	80.95
Indonesia	66.46	71.67	66.55	70.27	71.43	72.42	72.54

Source: Ministry of Environment and Forestry-Republic of Indonesia [60].

3.2. Variables

Two main variables were set to support this study. Both economic growth and environmental quality play a role as independent variables and dependent variables to explain causality between one another. Operationally, economic growth variables are extracted from GRDP data on the basis of constant prices, while environmental quality is based on IKLH. Table 3 details the variable composition. Referring to the variable entities collected, this study was inspired by similar research [17–24,28]. The data duration only focuses on the contemporary period of six years in PPU as the central area and the four *IKN* support zones mentioned above.

Table 3. Profile of variables.

Variable Name	Source	Parameter	Observation Period
Economic growth	Central Statistics Agency-East Kalimantan [59]	Percent (%)	2017–2023
Environmental quality	Ministry of Environment and Forestry-Republic of Indonesia [60]	Index (points)	2017–2023

3.3. Analysis Method

The first method for processing data is operated by panel data regression. This method functions to tabulate data quantitatively. Panel data regression is operated via computer software called IBM-SPSS. Methodologically, panel data regression is directed at the Ordinary Least Square (OLS) model. OLS-based panel data regression combines cross-section and time series data. There are two flows in regression data analysis. First, descriptive statistics and correlation have the aim of recapitulating variations in variable data and correlation coefficients. The value of the coefficient has an interpretation based on five classes, e.g., no correlation (0), weak correlation ($-0.3 \leq r < 0$ or $0 < r \leq 0.3$), moderate correlation ($-0.7 \leq r < -0$, 3 or $0.3 < r \leq 0.7$), strong correlation ($-1 \leq r < -0.7$ or $0.7 < r \leq 1$), perfect positive correlation (+1), and perfect negative correlation (-1). Second, a two-way panel data regression was carried out to test the empirical relationship between economic growth and environmental quality and vice versa. Logarithm (*log*) was used to simplify the units of account for variables. Below is the basic equation in panel data regression:

$$Y_{it} = \alpha + \sum_{k=1}^{K} \beta_k X_{k_{it}} + \mu_{it} \quad (4)$$

where Y_{it} (the dependent variable is the ith observation unit and the tth time), α (intercept), K (the number of independent variables), $X_{k_{it}}$ (value of the kth independent variable for the ith cross-section and tth year), β_k (slope coefficient), and μ_{it} (error in the ith observation unit and tth year).

Based on the econometric function above, the study variables are transformed into statistical symbols as follows:

$$Y_{Eg} = \alpha_1 + log\beta_1 X_{Eq} + \mu_1 \quad (5)$$

$$logY_{Eq} = \alpha_2 + \beta_2 X_{Eg} + \mu_2 \quad (6)$$

where Y_{Eg} (economic growth as dependent variable), α_1 (constant in first regression), β_1 (beta coefficient in the first regression), X_{Eq} (environmental quality plays a role as an independent variable), μ_1 (residuals in the first regression), Y_{Eq} (environmental quality is the dependent variable), α_2 (constant in second regression), β_2 (beta coefficient in the second regression), X_{Eg} (economic growth is the independent variable), μ_2 (residuals in the second regression), and *log* (double *log*).

The second method for processing data uses linear trends. A linear trend is a trend (down and up) in the long term, such as an average change over time. The average shift can decrease or increase. There are two outcomes in this model, where, if the average change decreases, it is called a negative trend; if the average change tends to increase, then there is a positive trend. In terms of quantification, the type of linear trend that is applied is a linear trendline graph to highlight shifts in straight line data. A linear trend is a pattern in an independent variable with a period of the highest power of one. Linear trend describes the linear relationship between the independent variable and the dependent variable. Moreover, a linear trendline tries to find a straight line that best fits the pattern of growth or decline of the data over time. The use of a linear trendline allows us to analyze a linear pattern and predict how the data will change in the future based on existing trends. The linear trend has the form of a straight-line equation as follows:

$$Y = \alpha + \beta X \quad (7)$$

where Y (periodic data or trend value); X (time period); α (Constant of Y, if X = 0); and β (coefficient on X with slope).

To determine the trendline, first look for the α and β values. By knowing the values of both, a trendline can be created. Technically, linear trendline graphs also predict the strength of the model built with the output in the form of the coefficient of determination (r^2). Because the correlation score (r) has a range of $-1 \leq r \leq 1$, then r^2 has a range between $0 \leq r \leq 1$. The r^2 score has a range of $0 \leq r \leq 1$, which can be converted into a percentage. The equation function on r^2 is explained below:

$$r^2 = \frac{SS_{xy^2}}{SS_{x^2}.SS_{y^2}} \quad (8)$$

where r^2 (coefficient of determination), SS (sum of squares), x (independent variable), and y (dependent variable).

4. Results and Discussion

4.1. Main Findings

The orientation of this study is that PPU is the center of *IKN*, with four regions as *IKN* buffers, including Paser, Balikpapan, Samarinda, and Kutai Kartanegara. Through the panel data regression method, two main findings were obtained. First, descriptive statistics and correlation were obtained. Specifically for correlation, this study uses two types of correlation, e.g., parametric correlation (Pearson) and non-parametric correlation (Kendall's tau and Spearman's rho). Of these two qualifications, parametric correlation is a correlation analysis carried out on parametric data to examine the relationship between

variables. Parametric correlation analysis is often also called the Pearson coefficient. Non-parametric correlation is a statistical technique adapted to measure the relationship between two variables without assuming a normal distribution of data. Non-parametric correlation is also known as non-linear correlation. Table 4 displays descriptive statistics based on four dimensions, i.e., mean, median, maximum, minimum, and standard deviation (SD).

Table 4. Descriptive statistics and correlation coefficients.

Items	Economic Growth	Environmental Quality
Mean	4.05	73.75
Median	4.84	74.17
Maximum	6.89	86.88
Minimum	−2.90	61.94
Std. deviation	2.45	5.80
Pearson	0.959 (0.009) **	
Kendall's tau	0.580 (0.016) *	
Spearman's rho	0.587 (0.037) *	
Obs.	35	35

Symbol notation: * $p < 0.05$ and ** $p < 0.01$.

In economic growth, the mean score is 4.05, the median score is 4.84, the maximum score is 6.89, the minimum score is −2.90, and the SD score is 2.45. This is different from environmental quality, where the mean score is (73.75), median score (74.17), maximum score (86.88), minimum score (61.94), and SD score (5.80). Based on a degree of probability below 1% ($p < 0.01$), the Pearson correlation explains that there is a very strong and significant interaction between economic growth and environmental quality or vice versa with a coefficient ($r = 0.959$) and probability ($p = 0.009$). But, through a probability level below 5% ($p < 0.05$), both Kendall's tau correlation and Spearman's rho correlation, it is concluded that there is a significant moderate interaction between economic growth and environmental quality and vice versa with a coefficient ($r = 0.580$; $r = 0.587$) and probability ($p = 0.016$; $p = 0.037$).

Second, Table 5 recapitulates the panel data regression in the two-way relationship between economic growth and environmental quality and vice versa. Referring to model 1, economic growth has a significant positive impact on environmental quality. This is proven by a probability degree of 1% ($p < 0.01$), whether constant, partial, or simultaneous, and economic growth has an effect on environmental quality with t-statistics and constant probability ($t = 37.909$; $p = 0.000$), t-statistics and partial probability ($t = 3.052$; $p = 0.009$), and F-statistics and simultaneous probability ($F = 4.065$; $p = 0.003$). Then, environmental quality also has a significant positive impact on economic growth, constantly, partially, and simultaneously. With a probability level of 5% ($p < 0.05$), environmental quality is able to influence economic growth with t-statistics and constant probability ($t = 8.693$; $p = 0.043$), t-statistics and partial probability ($t = 2.693$; $p = 0.027$), and F-statistics and simultaneous probability ($F = 2.485$; $p = 0.023$). The standard error value in model 1 ($SE = 5.883$) is higher than in model 2 ($SE = 3.767$).

Linear trend analysis based on linear trendline graphs from both models is visualized in Figures 4 and 5. In model 1, Figure 4 confirms that the data are identified with varying trends. Most of the data experiences positive trend changes with a tendency at the top right, while a small portion of data for several years is grouped at the top left (negative trend). In other words, the data material used is suitable for analysis. The performance in model 1 is quite good. Kurniawan et al. [61] state that r^2 is looking at the proportion of variation in the dependent variable that can be predicted from the independent variable. The function r^2 provides a measure of how well the observed results are replicated by the

model based on the proportion of total variation in the results explained by the model. The five patterns in r^2 correspond to the coefficient interval, and the influence levels include 0–19.99% (very weak), 20–39.99% (weak), 40–59.99% (moderate), 60–79.99% (strong), and 80–100% (very strong). The coefficient of determination in model 1 (r^2 = 0.608) falls within the coefficient interval between 60 and 79.9%, so economic growth has a strong influence on environmental quality. With an r^2 value of 60.8%, the remaining 39.2% are elements not discussed in model 1.

Table 5. Panel data regression results.

Items	Model 1 (Economic Growth → Environmental Quality)	Model 2 (Environmental Quality → Economic Growth)
Constant	37.909 (0.000) **	8.693 (0.043) *
Coefficients	0.959	0.493
t-statistics	3.052	2.693
Prob.	0.009 **	0.027 *
Lower bound	−0.817	−0.146
Upper bound	0.860	0.153
F-statistics	4.605	2.485
Prob.	0.003 **	0.023 *
Std. error	5.883	3.767
Obs.	35	35

Symbol notation: * $p < 0.05$ and ** $p < 0.01$.

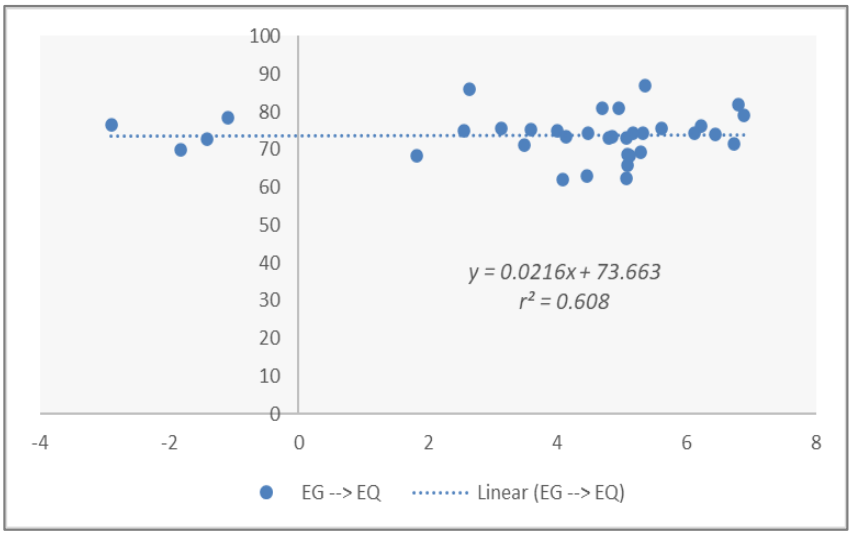

Figure 4. Linear trendline graph in model 1.

Slightly different from the linear trend in model 1, the linear trendline graph in model 2 shows that although the majority of the data is also in the top right position, a small portion of the data is actually clustered in the bottom right. Most of the average changes in data vary or experience an abnormal trend (from positive to negative). This indicates that there is a shift in environmental quality data toward economic growth, which tends to decline. The coefficient of determination in model 2 (r^2 = 0.562) is in the coefficient interval between 40 and 59.99%, where the environment has a moderate influence on economic growth. Figure 5 also justifies that with an r^2 value of 56.2%, the other 43.8% are confounding factors outside model 2.

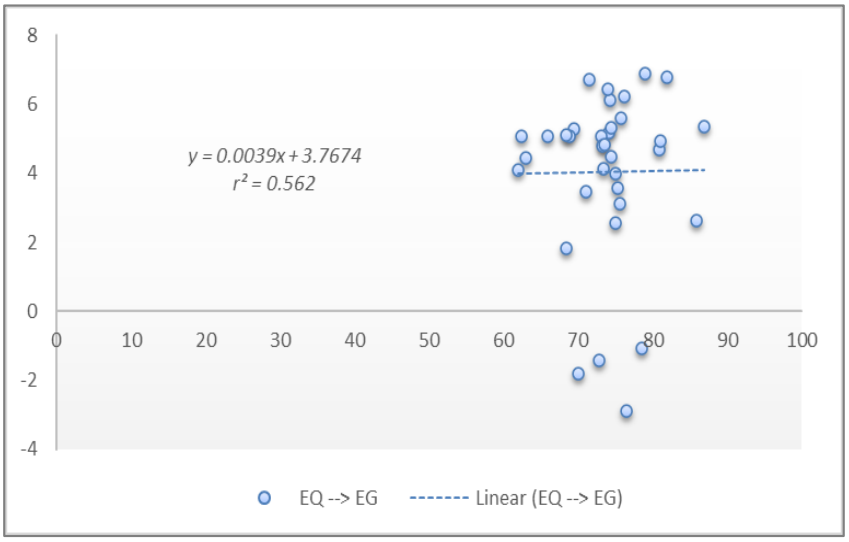

Figure 5. Linear trendline graph in model 2.

4.2. Implications

With the presence of IKN, economic growth has had an impact on environmental quality in recent periods. The existing phenomenon indicates that when economic growth increases, environmental quality is still well maintained in the short term. Yet, in the long term, increasing economic growth will bring negative risks to environmental quality.

The trade-off between consumption and non-renewable resources suggests that to increase consumption, the opportunity cost will result in a smaller supply of non-renewable resources. Throughout the last century, the rate of global economic growth has caused a decline in the availability of natural resources, such as logging and demand for wood to clear agricultural land; depletion of gas, coal, and oil; over-exploitation of fishing; extinction of species; and fragile biodiversity.

The validity of the Kuznets Curve for some characteristic pollutants is visible but is refuted for less visible and more diffuse pollutants (such as CO_2). The "U" shape favors pollutants but not natural resource stocks. It is claimed that economic growth has not reversed the trend to reduce the quantity of non-renewable resources and the proportion of consumption. Reducing pollution in one country will actually encourage the outsourcing of pollution to other countries, for example, importing coal from developing countries. Garbage is also one of the root causes of environmental pollution. Shallow insight into waste handling can bring new disasters, such as pollution. Indonesia has complex challenges regarding waste. There is overlap in determining policies. Often, discrepancies are found between waste management and control across organizations. Overall, apart from domestic waste, excessive waste imported from certain countries is difficult to recycle. The paper and plastic waste that has piled up at the Final Processing Site (TPA) cannot yet be recycled skillfully. These two types of waste are imported from outside Indonesia to meet industrial needs but tend to ignore environmental sustainability.

The argument on the relationship between economic growth and the environment involves several versions. Chakravarty and Mandal [62], Grossman and Krueger [63], Priyagus [64], and Yang et al. [65] argue that economic growth always leads to environmental damage. Uniquely, there are some who clarify that consistent economic growth can bring improvements and have an impact on stability [9,66]. In the next model, it is believed that the free market will not solve the problem due to uncertainty about air quality and the accumulation of other spillover effects on future generations. The impact of existing environmental pollution cannot be handled by the current price mechanism.

During 2017–2023, the results of the investigation detected that environmental quality drives economic growth in a positive direction. These findings signal that the more environmental quality is improved, the more it will have a significant effect on economic growth in the short term. However, there is a negative potential for economic growth if the environmental quality in *IKN* is ignored. Poor environmental quality will spur a slowdown in economic growth in the long term. Along with the current development of excessive needs, the environment was very essential in previous decades, especially when entering the industrial revolution. Experience from the 19th century to the 20th century shows that the exploitation of oil and coal was used as an energy source in every industrial investment to stimulate economic growth [67,68]. In the conservative economic literature, it is widely accepted that resource access tends to be expansive, whether renewable or non-renewable energy [69].

Despite its popular historical perception at that time, many observers and scholars saw that the environment was "two opposing sides of a coin". In reality, the natural environment provides economic growth through its positive contribution to national income. This also poses a threat to long-term economic growth because it can damage other sectors [70]. This weakness can trigger severe poverty, authoritarian regimes, social conflict, and even civil war. This side effect is called the "crowding out effect", describing countries that are rich in natural resources but have a fragile financial system and institutional structure, but does not bring industrial growth as expected. Based on many studies from previous publications, it is reasonable to say that natural resources are considered nothing more than a curse rather than a blessing [71].

The environment enjoyed by humans today comes from natural resources. There is a connection between the environment and economic growth, which is a multidisciplinary discussion. The environment is a criterion for assessing the sustainability of development for many countries [72,73]. Sachs and Warner [74] prove that economic growth in countries rich in natural resources is much lower than in countries with few natural resources. This anomaly is known as the "natural resource curse" based on a compilation of literature that consistently applies various econometric scenarios [75–77].

EKC's research history is rich, with most studies highlighting the link between economic growth and the environment and vice versa, as visualized in Table 6. Based on an empirical review of a cross-section of publications from 2020 to 2024, similarities with existing research were found. The scattered investigations from across cases fall into two points. The first is the investigation of the effect of economic growth on the environment. The second is the investigation of the effect of the environment on economic growth. Wulandari and Hayati [78] concluded that economic growth and environmental degradation in Indonesia from 1981 to 2017 had a significant integration. An increase in economic growth triggers structural damage in the long run. Economic growth has a one-way causality on CO_2 emissions. Liu et al. [21] related GDP per capita to terrestrial carbon sequestration capacity within the scope of low-income, lower-middle-income, and upper-middle-income countries in the tropics during 1995–2018. They concluded that GDP per capita significantly affects terrestrial carbon sequestration capacity in low-income and lower-middle-income countries, but there is an insignificant impact on countries with upper-middle income levels. Raihan et al. [79] investigated the potential of economic growth on CO_2 emissions in Malaysia from 1990 to 2019. The empirical findings show that an increase in economic growth is positively associated with CO_2 emissions.

Table 6. Comparison between past studies.

Authorships	Variables (Substance)	Model	Sign
Wulandari and Hayati [78]	Economic growth → Environmental degradation	Vector Error Correction Model (VECM)	+
Liu et al. [21]	GDP per capita → Terrestrial carbon sequestration	Panel Model	+
Raihan et al. [79]	Economic growth → CO_2 emissions	Dynamic Ordinary Least Squares (DOLS)	+
Leonardo et al. [80]	Economic growth → Environmental degradation	Error Correction Model (ECM)	+
Humbatova et al. [81]	Economic growth → Ecological environment	Autoregressive Distributed Lag (ARDL)	+
Osuntuyi and Lean [82]	Economic growth ↔ Environmental damage	Fully Modified Ordinary Least Squares (FMOLS), DLOS, PMG-Autoregressive Distributed Lag (PMG-ARDL), and Common Correlated Effects Mean Group (CCEMG)	+
Dardouri and Smida [83]	GDP → Ecological footprint	PMG-ARDL	+
Yu et al. [84]	Economic growth → Environmental damage	Two-Stage Least Square (2SLS)	+
Acheampong and Opoku [85]	Environmental degradation → Economic growth	Moments Technique Method with Global Panel	-
Xu et al. [86]	Carbon → Inflation	Ordinary Least Square (OLS) Regression	+

Leonardo et al. [80] examined the probability between economic development and environmental degradation in Indonesia through time series data during 1980–2021. Based on the EKC hypothesis model, economic growth in the early stage contributes to increased environmental degradation. Yet, the opposite is true after the turning point, where economic growth actually reduces ecological degradation. Humbatova et al. [81] analyzed the effect of economic growth on the ecological environment in Azerbaijan and Hungary for the period 1997–2022. In both Azerbaijan and Hungary, the quantity of economic growth had a significant effect on environmental pollution. Osuntuyi and Lean [82] initiated a study by linking economic growth and environmental damage in 92 countries during 1985–2018. The study findings show that economic growth is a long-term alternative to environmental degradation and vice versa in upper-middle and high-income countries but not for low-income and lower-middle-income countries. Dardouri and Smida [83] studied the relationship between GDP and ecological footprint in the G7 countries Germany, Japan, UK, USA, Canada, France, and Italy for the period 1961–2018. Under the "U"-shaped Renewable Kuznets Curve (RKC), GDP has positive implications for environmental degradation in both the short and long term. Yu et al. [84] examined the prospects of economic growth and environmental pollution in 230 Chinese cities. During 2004–2019, economic growth significantly worsened regional environmental pollution. This was because economic growth targets were overly ambitious and tended to maintain the economic growth position at the expense of the environment. At the same time, environmental regulations were relaxed, hindering sustainable environmental governance.

Acheampong and Opoku [85] navigated the connection between environmental degradation and economic growth of 140 countries during 1980–2021. In line with this, greater environmental degradation activities triggered a slowdown in economic growth. Xu et al. [86] calculated the impact of trade-offs between the environment and the economy. In this context, environmental variables are represented by carbon volatility, while economic variables use inflation rate indicators. In addition, a comprehensive investigation was directed based on the EKC framework in the carbon market of mainland China with three representative regions in the pilot projects of Shenzhen, Guangdong, and Hubei as the study objects from 2013 to 2022. In the pilot stage, inflation does not affect carbon returns, which contradicts the EKC model. After the threshold was added to the regression model, inflation had a linear impact on carbon returns. In the analysis sample in Guangdong and Shenzhen, the findings show an anomalous "inverted U"-shaped relationship between inflation and carbon returns, while a "U"-shaped relationship occurs in Hubei.

Environmental sustainability requires attention to encouraging inclusive economic circulation without the excessive depletion of resources [87–90]. In cases across nations, including European Union countries, the relevance of economic growth to environmental quality is reflected in government programs [85,91]. Policies such as minimizing waste and emissions, ensuring more efficient production processes, using environmentally friendly products and services, and promoting energy-efficient products can influence environmental sustainability in the future. These policies are expected to encourage economic growth, which will provide broad benefits (such as increasing living standards). Also, high economic growth can bring changes to the environment, such as the use of natural resources, waste, and pollution in recycled products. Strategic steps have also been taken by the Indonesian government by involving economic stakeholders in implementing a green economy through renewable energy, organic agriculture, social forestry, and ecotourism [92].

Amidst the challenges toward sustainable development, Indonesia is taking concrete steps through the green growth movement [93]. This policy includes using natural capital responsibly, reducing pollution, and optimizing opportunities to increase social prosperity. Building an exponential green economy is carried out by encouraging the efficiency of natural resource consumption costs while maintaining economic productivity. For example, Indonesia includes two pillars from the Sustainable Development Goals (SDGs) to realize sustainable green economic growth by 2030. These two pillars are SDG 7: "*To Ensure that Everyone has Access to Affordable, Reliable, Sustainable, and Modern Energy*" and SDG 1: "*To End Poverty in all forms by 2030*". There are three indicators from the two SDGs that synergize with each other: first, for SDG 7, pillar 7.2.1: renewable energy mix and 7.3.1: primary energy intensity; second, in SDG 1, pillar 1.4.1: percentage of households and vulnerable people with mains electricity sourced from the State Electricity Company (PLN) and non-PLN electricity. The renewable energy mix is targeted to reach 10–16%, and primary energy intensity is targeted to decrease by 1% per year or the equivalent of 463.2 barrels of oil, while 40% of the lower-middle-income population is targeted to have complete access to lighting (100%). This evidence was validated by the study by Suparjo et al. [94], where primary energy, renewable energy mix, and primary electrical lighting sources integrated into SDG's policies have a significant multiplier effect on green economic growth. The findings above clearly indicate that the three indicators based on the two SDGs pillars are valuable instruments in prioritizing the achievement of a green economy without sacrificing social prosperity, especially environmental aspects.

5. Conclusions

This study aims to test the two-way causality between economic growth and environmental quality. The data material was investigated for seven periods by adopting panel data regression and linear trends. As a result, it was found that economic growth in the area around *IKN* triggered environmental quality in a significant and positive way. Also, environmental quality has a significant positive impact on economic growth. Statistically, it can be interpreted that there is a strong model in the relationship between economic growth and environmental quality. In the second model, economic growth is influenced by environmental quality, with a moderate relationship. Both economic growth and environmental quality both influence each other and have a real impact. The strength of the closest relationship is economic growth to environmental quality compared to environmental quality to economic growth.

The analysis findings based on panel data regression and linear trends will be a follow-up for stakeholders, especially the government. Ideally, economic development in *IKN* and the surrounding buffer areas must coexist with environmental principles. The government has a preference for making policies that pay attention to environmental impacts as a consequence of accelerated economic growth. The government needs to determine alternative strategies to ensure inclusive economic growth while maintaining environmental sustainability. Inclusive economic growth is economic growth that maintains a balance with environmental quality. The weakness of this study lies in the limited data units and variables. For future research, we can consider the weaknesses of existing research by expanding the method.

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Sustainability Reporting in the University Context—A Review and Analysis of the Literature

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Abstract: This paper aims to determine the key themes addressed in sustainability reporting in higher education institutions (HEIs), focusing on papers indexed in the Scopus database until October 2024. The number of papers selected was fewer than the number of articles addressing sustainability reporting in corporate settings. We present the findings of this search by providing some metrics and an analysis of the selected texts through the construction of ten categories and 26 subcategories. Our study differs from previous works by providing an analysis of the content of some of the reviewed articles.

Keywords: universities; higher education; sustainability reporting; university management

1. Introduction

Sustainability reporting is a highly relevant source of information for assessing and reporting on the economic, environmental, and social dimensions of business activities [1,2]. However, in the case of universities or HEIs, sustainability reporting is a more recent and less well-established phenomenon than in the business or corporate sectors [3].

Sustainability reporting is a critical avenue for organisations to demonstrate their governance, accountability, and transparency to stakeholders [4]. Thus, the disclosure of sustainability reports meets the changing needs for information and transparency in the sustainable development performance of HEIs, and contributes to improving the levels at which the results of actions developed by HEIs in the framework of their corporate governance, are communicated and engage with society in an active way. The practice of accountability is, therefore, a key element of transparency: it fosters trust in the performance of organisations within society, and universities are proactive in informing stakeholders about their actions. This practice of accountability forces us to reflect on the impact of our actions on the organisation's environment. It is especially important to provide sustainability reports that involve the economic-financial, social, and environmental components of university activity, which constitutes a priority established by the 2030 Agenda.

In view of the above, the aim of this paper is to determine the key themes addressed in sustainability reporting within higher education institutions (HEIs). To this end, a systematic literature review of key aspects of sustainability reporting in HEIs was undertaken. Our literature review focuses on sustainability and sustainability reporting in HEIs discussed in documents indexed in the Scopus database until October 2024, systematising the publications by their respective authorship data and categorising them into those topics that represent the issues addressed by their authors. The following sections first

address the theoretical framework and addresses some previous work and a few concepts, followed by the methodology, which describes the procedure used to analyse the data, then Section 4, which presents the findings of the search by providing some metrics and analysis of the texts found through the construction of categories and subcategories, and finally, the conclusions.

2. Theoretical Framework

The United Nations [5] highlighted the need to be aware of natural resources and their use in light of future generations. This marked one of the starting points for the emergence of the concept of sustainability. From this, organisations became interested in voluntarily reporting their contributions to society, beginning the trend of Corporate Social Responsibility (CSR). Sustainability reporting by universities is still in its early stages compared with corporate reporting; however, in recent years there has been improvement in both the quantity and quality of disclosures [3,6]. Various authors [3,7] indicate that there is a pressing need to present timely information on the actions of universities within the framework of the various relationships that the academic community weaves as a political actor within a society. Although sustainability reporting in HEIs is not a recent topic, it remains a subject that has received little attention, with a low volume of scientific publications that address the issues inherent to the subject of university corporate governance.

Nevertheless, relevant efforts exist to develop an inventory and context of the published literature to set a path for those who wish to enter this field of research. Currently, tools are used for the construction of reports, such as the Global Reporting Initiative (GRI) guidelines and the Graphical Sustainability Assessment in Universities [8]. However, the GRI guidelines may need adaptation for higher education contexts [9]. Reporting practices and forms vary across countries and institutions; furthermore, there are some cases of universities owned by foundations, where a more significant effort in reporting is observed than in public universities [10]. Among the challenges in reporting are the creation of consistent reporting standards and improvements needed in the institutionalisation of sustainability [11]. Moreover, some researchers even float the idea of including spiritual dimensions, such as honesty and fairness, in sustainability reporting [12]. Despite these remaining challenges, sustainability reporting is important for demonstrating institutional commitment to sustainable development [13].

Sustainability is involved in areas such as disclosure (indicators, tools, standards, disclosure factors, evaluation); education for sustainable development—ESD—(study plan, curriculum, subject contents, events and professional practices); sustainable campuses (waste management, environmental performance, innovations and projects that contribute to the optimisation of the use of natural resources in HEI facilities), among other areas. All of the above aim to be in consonance with the outcomes agreed in the 2030 Agenda, which orients efforts towards achieving quantitative goals [14].

In this paper, in order to identify what the sustainability reporting publications are about, previous work has been taken into consideration. These include the authors Ceulemans et al. [15], who conducted the first literature review covering articles from the period from 2000 to February 2014. The authors found that the subject matter already possessed a high interdisciplinary component. Their search catalogued 178 publications on sustainability evaluation, communication, indicators, and performance. At that time, the authors concluded that the implementation of sustainability reporting within HEIs was lagging. Another paper by Adhikariparajuli et al. [16], focused on CSR and disclosure in HEIs for the period 2004–2020 in the most representative English-language databases. The authors categorised 58 articles into implications of disclosure, emerging issues, limitations, and recommendations that serve the academic community in establishing policies and practices. In a further relevant study, Petera [17] focused his systematic literature review on articles published in the Web of Science (WoS) database from 2011 to mid-2022. The author reviewed 80 English-language articles on sustainability reporting in HEIs, noting that the

topic is relatively new and, therefore, there were few publications compared to the same search for corporations. The results focused on bibliometric information that provides information on authors, journals, citation counts, and institutional affiliation of authors, among other metrics. The three reviews agree that research on sustainability reporting in the 21st century remains relatively nascent, both for the implementation of sustainability reporting in universities and for considering it as an emerging area of research within the publications indexed in the most representative academic databases.

3. Materials and Methods

The approach we adopted in our study was informed by the work of Chueke and Amatucci [18], which provides a systematic methodology for constructing metrics. This methodology involves considering quantitative elements (bibliometrics) and qualitative elements (systematic literature review) for thematic analysis. We also employed the PRISMA method [19] to visualise the process of searching and filtering documents. Thus, we applied this approach to the documents that fit our research criteria, ensuring a rigorous and reliable process.

Our literature review search was carried out in Scopus database until October 2024, given the search terms used in the equation: TITLE-ABS-KEY ("Sustainability reporting" AND "University" OR "Higher Education"). This equation returned 173 documents, a significant number for the field of study. Thus, we refined the results and analysed them in two stages.

Firstly, the content was verified by considering the title, abstract, and keywords that coincided with the topic of study. Figure 1 presents the PRISMA diagram of the search and selection process of relevant documents for this systematic literature review. As mentioned above, 173 documents were identified using the equation: 17 papers only considered company sustainability reports; 20 documents considered education issues but did not consider sustainability reporting; finally, 34 papers had no reference to sustainability reporting. In this way, only 102 articles dealing with sustainability reports issued by universities or higher education institutions in different countries were included.

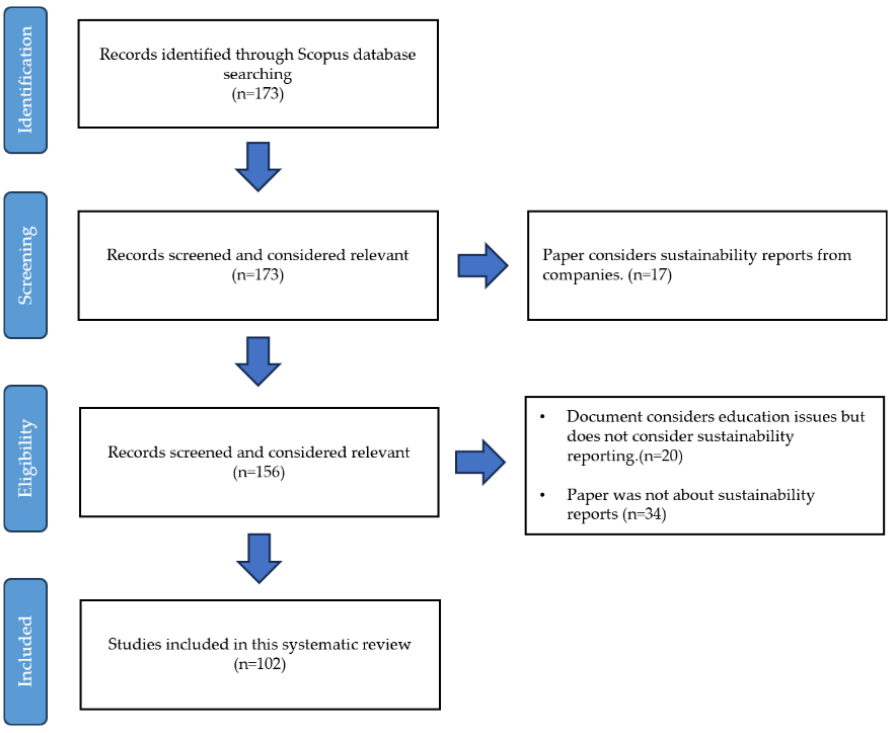

Figure 1. PRISMA Flow Diagram and Identification of Relevant Studies. Source: Elaborated by the authors and based on Moher et al. [19].

These documents were systematised to obtain quantitative metrics: articles were organised by year, number of authors, gender of authors, institutional affiliation, countries, and number of citations in Scopus and journals. The second stage consisted of a classification of the articles based on categories and subcategories that included a review of the issues addressed in them, in consonance with our study objective. Therefore, at the same time as each article was categorised, we also refined our inclusion criteria, leaving 102 documents for final analysis.

4. Results

Before addressing the results, recall that 102 papers were selected after filtering the research according to the criteria set out in the previous section. Thus, the first papers selected for this study date from 2011; this starting date of analysis arose as a consequence of the documents' identification and selection process. Figure 2 shows the distribution by year of the 102 papers dealing with information on university sustainability.

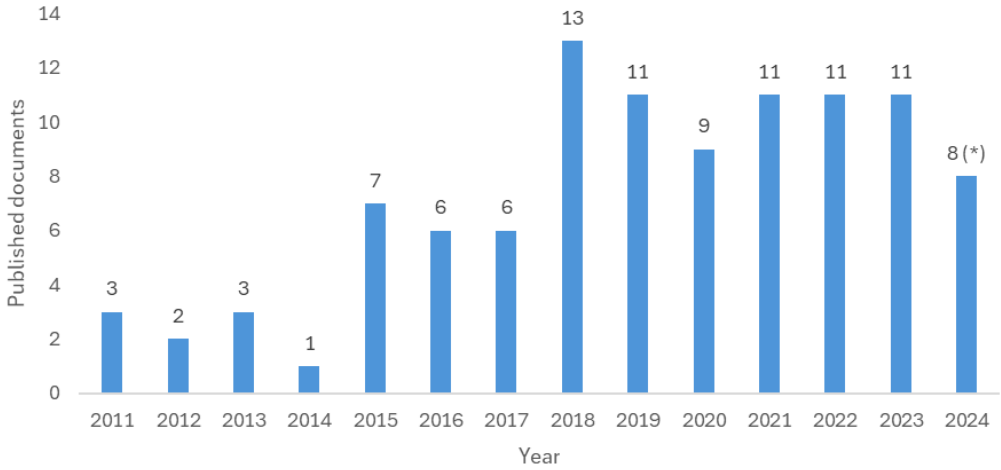

Figure 2. Articles by year. Source: Elaborated by the authors. (*) Until October 2024.

While the overall number of publications on sustainability in universities and other HEIs may be relatively low compared with other disciplines, a positive trend can be observed. From 2018 onwards, there has been a noticeable increase in the annual number of articles, indicating a growing interest in the field. This shift is particularly significant given that, in the early years, integrated reporting was not applied to the university environment—unlike in the business context where international sustainability standards have been in place for several decades.

The 102 selected papers were mainly classified as articles (82), followed by book chapters (13) and conference papers (7). As seen in Table 1, only five percent of papers were written by one author, while the fact that 95% were written by two or more authors indicates the importance of collaborative work. Indeed, papers with two, three, or four authors accounted for 71% of the publications. In total, 306 authors were involved in writing the 102 papers. With regards to the authors with the most publications within the sample, Ceulemans and Sassen stand out with five articles, followed by Lozano with 4 (Table 2).

Table 1. Number of authors per document.

	Number of Authors (a)								**Total**
	1	**2**	**3**	**4**	**5**	**6**	**9**	**12**	
Number of articles (b)	15	24	36	15	6	4	1	1	102
Total number of authors (a × b)	15	48	108	60	30	24	9	12	306
Total number of authors	5%	16%	35%	20%	10%	8%	3%	4%	100%

Source: Prepared by the authors.

Table 2. Authors with the most articles on sustainability reporting in higher education (2011–2022).

Ranking	Surname	Number of Articles
1	Ceulemans, K.	5
2	Sassen, R.	5
3	Lozano, R.	4

Source: Prepared by the authors.

Among the papers with the most citations until October 2024, three possessed more than 200 citations: Lozano [7] with 306 citations, Ceulemans et al. with 249 [15], and Alonso-Aleima et al. [20] with 233 citations (Table 3).

Table 3. Most cited articles on sustainability reporting in higher education (2011–2022).

Ranking	Article	Journal	Authors	Year	Refs.	Number of Citations
1	The state of sustainability reporting in universities	International Journal of Sustainability in Higher Education	Lozano, R.	2011	[7]	306
2	Sustainability reporting in higher education: A comprehensive review of the recent literature and paths for further research	Journal of Cleaner Production	Ceulemans, K. Molderez, I. Van Liedekerke, L.	2015	[15]	249
3	Diffusion of sustainability reporting in universities: Current situation and future perspectives	Journal of Cleaner Production	Alonso-Almeida, M.D.M. Marimon, F. Casani, F. Rodríguez-Pomeda, J.	2015	[20]	233
4	The state of sustainability reporting at Canadian universities	International Journal of Sustainability in Higher Education	Fonseca, A. Macdonald, A. Dandy, E. Valenti, P.	2011	[21]	193
5	Sustainability reporting and performance management in universities: Challenges and benefits	Sustainability Accounting, Management and Policy Journal	Adams, C.A.	2011	[22]	143

Source: Prepared by the authors.

The articles selected were published in 44 journals, as chapters in three books, and papers presented at five conferences. These papers, in turn, are concentrated in a few journals or instances—as shown in Table 4. In this table, only the names of journals, books, or conferences with two or more papers from the period of analysis are mentioned. The International Journal of Sustainability in Higher Education stands out, with 19 articles, which in total represent 18.4% of all the papers identified in the period.

Table 4. Journals, books, and conferences with the most articles on sustainability reporting in higher education (2011–2022).

Type	Names of Journals, Books, Conferences	Number of Documents
Articles	International Journal of Sustainability in Higher Education	19
	Sustainability	9
	Journal of Cleaner Production	7
	Sustainability Accounting, Management and Policy Journal	4
	Administrative Sciences	3
Book chapters	World Sustainability Series	10
Conferences	ACM International Conference Proceeding Series	3

Source: Prepared by the authors.

The papers were written by authors based at institutions from 33 countries, primarily in developed countries. The top four, according to Table 5, were based in Italy, Germany, Spain, and the USA.

Table 5. Number of documents by country.

Country	Documents
Italy	17
Germany	12
Spain	12
United States	12
China	8
Australia	7
United Kingdom	6
Canada	5
Netherlands	5
Others (24 countries)	50
Total (33 countries)	102

Source: Prepared by the authors.

In the case of the publications from Italy, researchers were interested in reporting on the processes developed within HEIs and universities to tackle sustainability-related issues. They considered international sustainability frameworks both from the business sphere applied to HEIs and those developed for the needs of HEIs and universities. The publications also investigated sustainable campus practices and strategies for linking the academic community to participatory scenarios of sustainability and education in order to guarantee a transversal view of the university's contribution to society's environmental problems.

The review found that the total number of institutions to which the authors could be linked was 158. Table 6 shows the top four institutions with the most authors who had affiliations, with the University of Hamburg in first place with six authors.

Table 6. Authors' institutional affiliation.

N°	University	Authors	Country
1	University of Hamburg	6	Germany
2	Nelson Mandela University	4	South Africa
3	University of Cadiz	4	Spain
4	University of Leuven	4	Belgium

Source: Prepared by the authors.

4.1. Categories and Subcategories

From reviewing and analysing the 102 documents, ten categories and 26 subcategories could be constructed (Table 7). This analysis not only allowed for categorisation but also led to the identification of possible research areas to further develop or deepen. Note that the evaluation category is where most papers have been classified (36), and the categories of information materiality (1) and university governance (2) are where the fewest papers were classified.

The following section of the document describes the ten categories outlined above, with a table explaining each of the subcategories and the authors of the classified papers.

Table 7. Articles by category.

N°	Category	Subcategory	Number of Articles	Total
1	Evaluation	Sustainability performance	12	36
		Sustainability performance—Components	10	
		Sustainability performance—Quality	5	
		Campus-sustainability practices	4	
		Process	3	
		Model	2	
2	Dissemination	Motivations and obstacles	6	20
		Media	5	
		Corporate governance	3	
		Tools	6	
3	Implementation	Trends	6	17
		Sustainability practices	6	
		Instrument	5	
4	Stakeholders	Perception	1	9
		Participation	8	
5	Agenda 2030	SDG compliance	2	7
		SDG commitment	2	
		Integration of SDGs in HEIs	3	
6	Education for sustainability	Curricular intervention	3	4
		Gender diversity	1	
8	Sustainability	Sustainability dimensions	3	3
7	Impact	University Ranking	1	3
		Organisational change management	2	
9	University Governance	University sustainability strategies—SDGs	1	2
		Governance transformation	1	
10	Materiality of information	Disclosure practices	1	1

Source: Prepared by the authors.

4.1.1. Category: Evaluation

The evaluation category reveals how sustainability reports assess universities' organisational performance in sustainable development (Table 8).

Table 8. Subcategories of evaluation.

Subcategory	Some Authors
Sustainability performance: These studies compare the sustainability reports disclosed by HEIs concerning the standards and information provided to identify their level of ownership of sustainability (11 results in this subcategory); an increased interest of universities in sustainability reporting can be observed in the last decade of the 21st century.	Sari and Faisal [23] Yalin et al. [24] Yáñez et al. [25] Capocchi et al. [26] An et al. [27]
According to the GRI database, 81 HEIs (249 units of analysis) published sustainability reports during the last decade (2010–2020). This is a very low proportion (0.2%) compared to the total number of HEIs in the world (33,647).	Habib et al. [28] Melles [29] Easter et al. [30]
Western countries are innovators in sustainability reporting. In line with the above, the articles classified in this subcategory locate case studies of HEIs in China, Spain, Italy, and Pakistan, evidencing the increased interest of developing countries and emerging economies in presenting findings in this area of research.	Pelcher et al. [31] Zheng et al. [32] Hajawiyah, Raharja and Pamungkas, [33] Pramono et al. [34]

Table 8. *Cont.*

Subcategory	Some Authors
Sustainability performance—Components: These studies verify the relevant elements of sustainability reporting. Thus, HEIs must adopt a framework for sustainability reporting that ensures metrics contribute towards producing credible results, emphasising monitoring and control within the data analysis process, i.e., it is essential for legitimising the information provided from areas of knowledge such as accounting. Such evaluations have been presented in Canadian, US, Austrian, German, New Zealand, and South African settings. In short, the aim here is to promote greater accountability, better performance (management), and innovation in HEIs approach to sustainability.	Lozano [3] Sassen and Azizi [35] Fonseca et al. [21] Sassen and Azizi [36] An, Davey and Harun [37] Calitz et al. [38] Adams [22] Huber and Bassen [39] Lopatta and Jaeschke [40] Chaudhary and Trivedi, [41]
Sustainability performance—Quality: These papers comprehensively assess the structural information to be disclosed in the reports considering the impact of HEIs within society; for this purpose, strengths and weaknesses of sustainability reporting practices among these institutions are broken down. Sepasi et al. [42] noted that HEIs should: 1. develop their overall strategies with sustainability integration and not the other way around; 2. narrow the value-action and performance-disclosure gaps by understanding their role in promoting the SDGs; 3. adopt sustainability-related topics within the curricula, in addition to developing sustainability leaders; 4. be sustainability policy makers for HEIs to integrate sustainability efforts at the higher level. Related case studies of French HEIs are presented by Chatelain-Ponroy and Morin-Delerm [43], based on two dimensions.	Romolini et al. [6] Sepasi et al. [42] Chatelain-Ponroy and Morin-Delerm [43] Kräusche and Pilz [44] Bice and Coates [45]
Campus-sustainability practices: These articles present practices implemented directly on the university campus. Given that "universities face different social, environmental and economic scenarios in response to the implementation of the SDGs in an era of climate change" [11] (p. 969), awareness of their practices in relation to the use of natural resources and the actions their academic community takes towards the environment are of vital importance. Among the tools used to quantify the practices implemented on campus, BioBlitz stands out, which involves generating an inventory of biodiversity on campuses. Likewise, university sustainability framework initiatives have been relevant in the European context; for example, the Sustainability Code for Universities (GSC-U) is inspired by the implementation of the German Sustainability Code for Universities; more universities are reporting, but Helling [46] notes that it is essential to create incentives that motivate universities to implement the standard. It would thus be desirable for universities to be obliged to report on sustainability, and this could certainly increase the number of GSC-U users.	Melles et al. [11] Ryan-Fogarty et al. [47] Helling [46] Townsend and Barrett [48]
Process: These studies evaluate the process of preparing the information. The aim here is to provide an in-depth look at the complexities of the sustainability reporting process in higher education, in the sense that "the practice of sustainability reporting has been identified as one of the tools to foster the integration of sustainability in HEIs" [49]. Concerning this, the actions required by HEIs to disclose their practices in sustainability reports involve both internal and external agents where data is collected, classified, and validated to recognise those efforts that contribute to the environment and society, considering the high demand for transparency and accountability required for the use of public resources, legitimising the integrative and transformative role of HEIs in society.	Ceulemans et al. [49] Brusca et al. [50] Ceulemans et al. [51]
Model: These papers present guidelines designed to assess sustainability reporting in higher education. In their research, Madeira et al. [52], built a model based on the role of HEIs in stakeholder relations and their main functions, placing education and research at the centre and giving importance to university governance in terms of sustainability policies. Sepasi et al. [53] concluded that most sustainability reporting frameworks in the corporate context contain consistent and context-appropriate indicators. This situation does not apply to HEIs within the same timeframe.	Madeira et al. [52] Sepasi et al. [53]

Source: Prepared by the authors.

4.1.2. Category: Disclosure

This category presents the way in which universities communicate sustainability reports to their stakeholders so that there is greater awareness of the actions, programmes, and projects that have been consolidated within HEIs (Table 9).

Table 9. Subcategories of disclosure.

Subcategory	Some Authors
Motivation and Obstacles: These papers show the variables that favour or hinder the disclosure of sustainability reports; according to Sassen et al. [36], meeting society's expectations is one of the most relevant motivations, while the lack of organisational structures related to reporting represents the most important obstacle; therefore, HEIs need to know what, why, and how to report on sustainability. With regards to the most reported dimensions in sustainability reporting, there is a greater concentration on the environmental dimension without concern for the social dimension, which is evidence of the still incipient state of sustainability reporting.	Sassen et al. [54] Sassen et al. [36]
Media: This subcategory involves systematising those scenarios used to inform and make visible the sustainability reports that contribute to the socialisation process carried out by HEIs, where the web pages act as a space that allows for the activities developed by HEIs to be accounted for and to generate social and environmental awareness; however, to ensure the institutionalisation of sustainability reports, these should not be replaced by synthesised information on their websites. Furthermore, means of dissemination that are more timely and interactive for stakeholders should be linked; therefore, there is greater interest from HEIs in the elaboration of sustainability reports, which limits the data or information delivered on the web.	Son-Turan and Lambrechts [10] Nicolò et al. [55] Di Tullio and La Torre [56] Gavin Lai et al. [57]
Corporate governance: This subcategory considers how corporate governance is affected by changes in guidelines, where HEI boards are responsible for contributing to social responsibility processes in coherence with institutional strategies, hence the study by Nicolò et al. [55] analysed voluntary disclosure in the field of sustainability including practices carried out during the time of the pandemic by COVID-19, which led HEIs to deepen university governance. In particular, the role played by websites during the pandemic, as they allowed universities to demonstrate their commitment to address the social, economic, and political disruptions of the pandemic.	Nicolò et al. [55] Andrades et al. [58] Sun et al. [59]
Tools: These identify standardised models of sustainable disclosure that universities most commonly use; for example, the first tools studied by researchers are the Global Reporting Initiative (GRI) Sustainability Reporting Guidelines and the Sustainability Tracking, Assessment and Rating System (STARS) of the Association for the Advancement of Sustainability in Higher Education (AASHE), both of which address similar variables but have different structures for their presentation. While universities and countries have committed to various sustainability compacts, such as the "Higher Education Sustainability Initiative for Rio 20, only a few of them report on their sustainability efforts, and only a few use the GRI framework" [20] (p. 9). Additionally, it was found that there is also an important use of ISO 26000 and ISO 14000 [60], as well as social balance sheet formats that help the elaboration of sustainability reports contemplating financial and non-financial information from the perspective of social and environmental accounting.	Lozano et al. [7] Alonso-Almeida et al. [20] Castillo and Roberts [61] Mo and Wang [62]

Source: Prepared by the authors.

4.1.3. Category: Implementation

This category deals with the aspects that make sustainability reporting and reporting possible (Table 10).

Table 10. Subcategories of implementation.

Subcategory	Some Authors
Trends: These address the evolution of how sustainability reports have been implemented over time and show their transformation up to the present day. It highlights accountability through standardised reports, such as GRI reports, which allow the convergence of financial and non-financial information, evolution in the use of sustainability indicators and practices; case studies in Italian universities and the construction of university social responsibility frameworks stand out.	Moggi [9] Mauro et al. [63] Siboni et al. [64] Jiménez et al. [65] Sonetti et al. [66] Moggi [67]

Table 10. *Cont.*

Subcategory	Some Authors
Practices: These papers systematise ways of making sustainability visible within the university. They show the extent to which universities implement sustainability reporting in their everyday operations, describe the implementation process, and finally indicate that transparent sustainability reporting allows for a more connected engagement with stakeholders.	Leal-Filho et al. [13] Bizerril et al. [68] Kirrane et al. [69] Zorio-Grima et al. [70] Ceccarini et al. [71]
Instruments: These consider the tools for implementing sustainability reporting. The use of business intelligence (BI), which transforms university data into a competitive advantage, was highlighted as it helps with the visualisation, analysis, and reporting of information to improve decision-making in sustainability.	Calitz et al. [72] Scholtz et al. [73] Haupt et al. [74] Mandigma [75] de Guzman et al. [76]

Source: Prepared by the authors.

4.1.4. Category: Stakeholders

Stakeholders reveal how they use the information presented in HEI sustainability reports (Table 11).

Table 11. Subcategories of stakeholders.

Subcategory	Some Authors
Perception: This subcategory addresses how stakeholders view the nature and scope of sustainability reporting. Amoako et al. [77] found that stakeholders do not show interest in sustainability reporting; on the contrary, it fails to provide a comprehensive view of the subject due to the low level of implementation of the standard, thus rather focusing more on academic issues than on addressing environmental and social dimensions.	Amoako et al. [77]
Participation: These papers reflect how stakeholders are involved in developing and disclosing sustainability reports. For example, Crocco et al. [78] analysed the role, characteristics, and methods of stakeholder engagement within HEI sustainability reporting and how stakeholders are involved in sustainability integration.	Crocco et al. [78] Chakraborty et al. [79] Davey [80] Ferrero-Ferrero et al. [81] Klubmann et al. [82] Di Tullio et al. [83] Herzner and Stucken [84]

Source: Prepared by the authors.

4.1.5. Category: Agenda 2030

This category relates sustainability reports to the Sustainable Development Goals (SDGs) defined by the UN, contemplating how universities should lead on this issue within their mission functions; therefore, this category visualises the actions and disclosure practices oriented towards the SDGs by universities that, similar to companies, have paid attention to the issue (Table 12).

Table 12. Subcategories of Agenda 2030.

Subcategory	Some Authors
SDG compliance: This subcategory evaluates the SDGs' achievement level from the actions of HEIs, presenting an overview of the response of universities to the demands for sustainable information related to the 17 SDGs, where it was possible to identify the existence of heterogeneity in the ways information was disclosed.	Fiorani et al. [85] Hamilton and Waters [86]
SDG commitment: Papers in this subcategory are concerned with the evidence of the condition of taking responsibility for the SDGs, given that HEIs act as a bridge between the community and future professionals who will be linked to the labour market. They provide awareness of the academic community's responsibility to undertake joint actions that promote sustainable development.	Caputo et al. [87]
SDG integration in HEIs: This subcategory involves identifying the challenges HEIs face in integrating the SDGs into their everyday activities; in the words of Hansen et al. [88], there are significant challenges in integrating the SDGs into HEIs' actions, considering the stakeholders and their interaction within campuses.	Hansen et al. [88] Lakhno [89] Nikolaou et al. [90] Andrades et al. [91]

Source: Prepared by the authors.

4.1.6. Category: Education for Sustainability

This category concerns the incursion of sustainability reporting into the field of education within the academic community (Table 13).

Table 13. Subcategories of education for sustainability.

Subcategory	Some Authors
Curricular intervention: These account for the curricular changes incorporated as sustainability reporting is established within HEIs. Rodrigues and Morais [92] presented the Challenge Learning Method (CLM), so that teachers of accounting include in their subjects and from the curricula, knowledge about integrated reporting that considers financial and non-financial information that allows trained professionals to face the challenges of the future in terms of sustainability, taking into account that accounting and auditing must lead the process of sustainable disclosure. Kosta [93], in a UK study, considered a comprehensive institution-wide sustainability report as a method of benchmarking against in-house sustainability programme provision, finding that 7 out of 167 UK universities produce what STARS considers to be an optimal sustainability report, one that also includes a report on sustainability curricular provision.	Rodrigues and Morais [92] Kosta [93] Rüdele and Wolf [94]
Gender diversity: This presents the linkage of the gender variable within sustainability reporting. There is only one research study focused on this issue, finding that gender equality is often not prioritised in HEIs, and the literature has highlighted the need to address the issue in academia because, as HEIs report on sustainability, they engage in practices that contribute to the quality of life of the community and raise awareness of the value of diversity and inclusion within HEIs.	Oppi [95]

Source: Prepared by the authors.

4.1.7. Category: Sustainability

In this category labelled "sustainability", nature is conceived from a balanced and future-oriented perspective. Human actions must be coherent with the environment, achieving harmony with the social dimension (Table 14).

Table 14. Subcategories of sustainability.

Subcategory	Some Authors
Sustainability dimensions: These address the sustainability reports of universities, distinguishing the application of the three dimensions. The articles report on emerging economies and the application of comprehensive models.	Musyarofah [12] Ceulemans et al. [96] Hinson [97]

Source: Prepared by the authors.

4.1.8. Category: Impact

This category considers the interaction frameworks of the different actors or stakeholders that are linked to sustainability reporting (Table 15).

Table 15. Subcategories of impact.

Subcategory	Some authors
Ranking: These present evidence of the impact of sustainability reporting on their ranking in an international ranking.	Shan et al. [98]
Organisational change: These consider those processes, tools, and actions that contribute to the implementation and transformation of organisations. In this case, it is towards a transition to sustainability in universities, the integration of sustainability thinking in the university; this requires creating awareness in the academic community and its environment, allowing the management of relevant organisational changes. Sustainability reporting at the university level is considered to be at an early stage. Ceulemans [15] surveyed universities worldwide, and their results indicated that sustainability reporting leads to incremental changes, as it integrates dialogue between internal actors and stakeholders to implement actions for the university and its' holistic vision.	Ceulemans et al. [15] Washington-Ottombre [99]

Source: Prepared by the authors.

4.1.9. Category: Materiality of University Governance

The impact category analyses whether sustainability reporting affects or causes a change in another variable. University sustainability reporting was found to have a direct relationship with responding to stakeholder expectations with such disclosure, positively strengthening the perception of universities in university rankings [98] (Table 16).

Table 16. Subcategories of materiality of university governance.

Subcategory	Some Authors
University sustainability strategies: These show the lines of action that guide HEIs' sustainable practices, demonstrating that there is a solid basis to undertake action that addresses the SDGs. The article by Nelles et al. [100] identified the need for HEIs to have an administrative leadership that structures a comprehensive SDG implementation plan in order to incorporate sustainability into all university activities, such as research, teaching, and outreach. They also point out that data collection and reporting may not be adequate to address all SDGs and sustainability issues and that HEIs should share their experiences to report on how far they have come and present those actions that were key and those that need to be improved on.	Nelles et al. [100]
Governance transformation: These refer to the impact of sustainability reporting on governance; to this end, Gao and Liu [101] compare the evolution of sustainability reporting in the corporate world concerning HEIs, suggesting that there are corporate actions that would enrich campus management from a governance perspective.	Gao and Liu [101]

Source: Prepared by the authors.

4.1.10. Category: Materiality of Information

The materiality of information is information that is meaningful to the various stakeholders for decision-making purposes (Table 17).

Table 17. Subcategories of information materiality.

Subcategory	Some Authors
Disclosure practices: These systematise disclosure practices. The social and economic dimensions become more relevant to stakeholders concerning education/research and the environment. This may be because other voluntary communication instruments are more focused on locating information related to university rankings, research excellence reports, and awards. In this respect, HEIs mostly use the GRI G4 framework for their sustainability reporting. Here, a gap may exist between what internal and external stakeholders expect to find from the information provided in these reports, revealing a lacuna in reporting interests.	Lubinger et al. [102]

Source: Prepared by the authors.

5. Conclusions

While previous literature reviews on sustainability reporting and a bibliometric analysis exist, this article goes beyond merely analysing quantitative variables. Rather, it offers an analysis that unveils potential research topics by constructing categories and subcategories of interest, sparking curiosity and inspiration for further exploration.

The results of this study demonstrate that, although higher education institutions (HEIs) have begun to adopt sustainability reporting, this practice remains at an early stage. However, there is a growing trend towards recognising the key role universities' play in global sustainability. Despite progress in the systematisation and integration of metrics, significant opportunities exist to improve the quality, frequency, and scope of reporting.

Our analysis identified several main challenges for doing so. First, the need to standardise reporting through a framework specifically adapted to HEIs. Second, the importance of addressing dimensions beyond the environmental, such as social, cultural, and economic dimensions. Furthermore, the integration of the Sustainable Development Goals (SDGs) presents difficulties related to the materiality and representativeness of the data, limiting the ability of universities to demonstrate their impact in a concrete and measurable way.

Tools and methodological approaches such as the Global Reporting Initiative (GRI) guidelines and STARS vary considerably depending on the geographical and institutional context. As a result, these tools need to be customised to reflect the particularities of the higher education sector and promote effective institutionalisation of reporting.

Furthermore, the results suggest that the reports have the potential to positively influence public perception of universities, improve their position in international rankings, and strengthen stakeholder confidence. However, this impact remains unevenly distributed, as many institutions still lack effective mechanisms to implement comprehensive sustainability strategies and measure the success of their initiatives.

University engagement with the SDGs has progressed slowly, but solid foundations are being laid for more structured integration. Sustainability reporting is essential to assess and communicate progress but requires determined leadership that places sustainability as a cross-cutting theme in all institutional activities.

As HEIs play a crucial role in education and raising awareness regarding sustainable development, sustainability reporting would not only formalise this commitment but also promote cultural change, including the transformation of curricula, campus management, and the creation of strategic partnerships.

Among the challenges that emerge from this work is establishing a future research agenda that considers exploring hybrid reporting models that take into account qualitative and quantitative approaches, the impact of reporting on strategic decision-making, and developing more representative indicators to measure sustainability in the university context. It is also essential to investigate how universities can more actively involve stakeholders, including students, faculty, and local communities, in creating and evaluating their reports.

Finally, higher education institutions should adopt a more proactive role in developing and disclosing sustainability reports. The systematisation of categories and subcategories presented in this work not only allows for an assessment of the current status of the reports but also for the identification of priority areas for improvement. Furthermore, this paper highlights the importance of developing sustainability strategies involving stakeholders and utilising advanced technological tools. Ultimately, only through a sustained commitment to transparency and accountability can HEIs consolidate their role as leaders in implementing the SDGs and therefore respond effectively to today's challenges.

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Variability of the Level of Budget Expenditures on Social Insurance of Farmers in the Agricultural Policy of Poland After Accession to the European Union

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Abstract: The purpose of this article was to examine the level and variability of budgetary expenditures directed to the Agricultural Social Insurance Fund (ASIF) in Poland in the form of subsidies to the Farmers' Pension Fund in the period 2004–2024, i.e., after Poland's accession to the European Union (EU). The aim of the study was also to determine the share of subsidies to the farmers' social insurance fund in the total expenditures of the Polish agricultural budget, as well as the relationship of ASIF expenditures to state budget expenditures and GDP dynamics. The authors attempted to estimate the trend function for these time series and the degree of fit of the equations describing them. The formation of the nominal and real level of budget expenditures on the ASIF in 2004–2024 was evaluated. It was assumed that spending on the ASIF is an element of agricultural policy, realising its redistributive and social objectives, but indirectly also pro-development objectives by supporting generational change in agriculture. The research showed that the real level of spending on ASIF declined during Poland's EU membership, as did the share of this spending in the total agricultural budget. The subsidy to the social security system also did not follow the changes in GDP and state budget expenditure proportionally, showing much less dynamism over the period studied. This means that budget support for farmers' social security is losing its importance as an instrument of agricultural policy. It has been shown that the economic and social components of agricultural expenditure have not grown in harmony. The changes in the level of spending on the ASIF in the period 2004–2024 were also analysed in relation to demographic changes, i.e., the number of farmers insured in the ASIF and recipients of agricultural pensions. It has been shown that, despite a significant decrease in the number of farmers receiving pensions from the ASIF, there remains a large disparity between the average pension benefits of farmers and those of the general social insurance system (Social Insurance Institution—SII). The reduction in this disparity is not served by a real reduction in subsidies to the ASIF.

Keywords: agricultural policy; budget expenditure on the ASIF; agricultural budget; state budget; GDP

1. Introduction

One of the fiscal instruments used in agriculture, which is part of the broader agricultural policy, is the subsidisation of the farmers' social security system from the state budget. This form of public support for agriculture is used in many economically developed countries. In Poland, it has been implemented since 1991 in the form of a budget

subsidy to finance the objectives of the Agricultural Social Insurance Fund (ASIF). This subsidy fulfils one of the three basic functions of state fiscal policy, i.e., the redistributive function towards the population associated with agriculture [1,2]. Within the framework of agricultural policy, redistributive and social spending, which are not quite the same thing, compete with the economic objectives pursued by the other two fiscal functions, i.e., allocative and stabilising [3–6].

The redistributive function of fiscal policy refers primarily to the secondary distribution of income, which follows the primary distribution by the market mechanism. The premise of secondary income distribution is the demand for social justice. The equalisation of disparities achieved through fiscal policy is expected to lead to a reduction in income and wealth disparities between citizens. This is due to the fact that in the most developed countries there is no socio-political acceptance of the existence of a naturally occurring, deep income gap between farmers and other socio-professional groups [7–11]. European Commission data—for the 27 EU countries—indicate that in the years 2005–2022, the average income from a family farm (per full-time employee) compared to the average salary in the economy ranged from 26.5% to 64% [12]. This indicates the scale of the income disparity of farmers. There is also no consensus on the very high volatility of agricultural incomes, which is indicated by the data cited above. Similarly, there is no acceptance for low profitability of the assets involved in agricultural production, but also the unstable and rising food prices for consumers, which undermine food security [13,14]. Thus, the existing inefficiencies of the market mechanism in agriculture [15–19] are compensated by the use of instruments related to taxes and transfers [20–22].

This article examines public expenditure on supporting the functioning of the social insurance system for farmers in Poland for the period 2004–2024. Expenditure in the form of subsidies to the ASIF is financed from the state budget. The level of spending on the ASIF against the background of changes in the level and structure of the total agricultural budget, changes in state budget spending, and the dynamics of GDP indicates changes in the importance of spending on farmers' social insurance as an instrument of agricultural policy in Poland in the post-accession period.

The empirical research direction outlined above stems from the authors' theoretical motivation to highlight the article's innovative contribution to the development of agricultural economic theory. The theoretical aspects of agricultural economic research have already been presented in the literature on the subject [23]. On the other hand, we consider this article as a contribution to the development of the subject of agricultural economics, which is located in the research stream of heterodox economics, or more precisely, in the field of agricultural policy. The problems considered fit with the contemporary research on the agrarian question [24–26] and are included in the socioeconomics of agriculture and rural areas in the paradigm of permanently balanced development. It is worth noting here that heterodox schools of thought, along with orthodox (mainstream) economics, form a new, expanded paradigm of economics that takes into account more than a dozen research streams, including those related to social insurance for farmers and their families [24,27,28]. The variability of budget spending on farmers' social insurance in Polish agricultural policy, discussed below, is part of a broader, systemic problem of farmers' economic deprivation, expressed in the persistent long-term gap between agricultural and non-agricultural incomes [29,30]. This makes it impossible to pay a sufficiently high insurance premium. As a result, it tends to force increasing subsidies into the state agricultural budget. As this problem affects farmers in many countries, including those in the European Union, it can be considered a widespread problem that requires a systemic solution. This article highlights this problem and thus fills an existing research gap. The authors hope that it will encourage the initiation of research in this area. In the case of Poland, twenty years of EU membership

have exacerbated the problem under discussion. This is due to the fact that the past period has created a natural economic space for the reduction in disparities between the level of agricultural and non-agricultural insurance, which is determined, on the one hand, by the increase in the level and dynamics of national income and state budget expenditure in non-agricultural sectors of the economy and, on the other hand, by the decrease in the number of beneficiaries and taxpayers of social insurance in agriculture. This creates the possibility of a significant increase in the level of agricultural pensions and a reduction in their gap with the level of non-agricultural security.

We argue that budget expenditures to support the farmers' social insurance system are an important tool of agricultural policy that supports the sustainable development of agriculture. The subsidy from the state budget for farmers' social insurance is a guarantee of stability and an adequate level of pension and disability benefits for farmers and thus contributes to the durability of family farms and supports the processes of succession (generational changes) in agriculture. On the other hand, public support for the farmers' social insurance system reduces the burdens that agricultural producers would have to bear if the system were fully financed from their contributions. In this way, these expenditures support farmers' incomes. Furthermore, the application of a progressive scale of burdens from farmers' pension and disability insurance in relation to the area of agricultural land of the farm, as is the case in Poland, helps reduce income inequalities within the agricultural sector. As a result, public expenditures on the farmers' social insurance system can support the implementation of economic and social goals on the path of sustainable development of agriculture, and, indirectly, can also contribute to maintaining environmental (ecological) order by strengthening the model of agriculture based on family farms. However, the importance of public expenditure on farmers' social insurance as an instrument of agricultural policy depends on the scale of this support and its stability.

The purpose of this study is to assess the level and changes in budgetary expenditure directed to the Agricultural Social Insurance Fund (ASIF) in Poland, in the form of a budgetary subsidy to the Farmers' Pension Fund. The study covers the period 2004–2024, i.e., the period after Poland's accession to the European Union.

The premise of the research was that in the conditions of a significant lack of parity of agricultural and non-agricultural incomes in Poland, it is important that the redistributive function of the state fiscal policy follows the direction of proportional expenditure on the ASIF, with the level and dynamics of growth of GDP, total state budget expenditure, and national agricultural budget expenditure. The idea is to show to what extent public spending on social security for farmers (pensions) has grown harmoniously (or not) in relation to the above figures over the last two decades. This, in turn, will indicate the importance of spending on farmers' social security as an instrument of agricultural policy to achieve its redistributive and social objectives.

2. Literature Review

In countries such as the United States, Canada, and the United Kingdom, where the share of the agricultural sector in GDP creation has gradually declined, the extent of government preference for the agricultural population has generally decreased. This relates to the pension systems for farmers. In these countries, the farmers' pension scheme is part of the general social security system and farmers are treated as entrepreneurs. This does not mean, however, that in some of the countries mentioned above the pension systems for farmers are entirely market-based and not supported by public funds. For example, in the Canadian social security system, farmers are guaranteed a minimum pension based on the concept of a socioeconomic safety net. The solutions adopted in these countries are based on

the integration of the pension system with the contributory system, with a strong emphasis on the need to invest savings in financial markets [31,32]. European Union countries where farmers are covered by the universal social security system include Bulgaria, the Czech Republic, Denmark, Estonia, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden. In the social security systems of these countries, there is no organisational or structural distinction between the universal and agricultural systems, and the rules for paying contributions and granting benefits to farmers are—in principle—the same as for other occupational and social groups [33]. It should be noted that in Denmark, Estonia, Finland, the Netherlands, and Sweden, the classification of farmers' social security systems as universal systems refers to the base part of these systems. In these countries, basic social benefits are not related to employment and profession [34]. An example of a solution in which farmers are covered by the general social security system for self-employed entrepreneurs is Belgium. This system is separate from the employee system and has its own administrative structure and separate rules for paying contributions and granting benefits. Farmers participate in this system on exactly the same terms as any other entrepreneur [33,34].

In several EU countries, such as Poland, Austria, Finland, France, Germany, and Greece, the social insurance system for farmers has been separated from the general system and its tasks entrusted to a specialised institution [35–38]. The insurance institutions of the listed countries form a sectoral organisation representing their interests in the European forum—the European Network of Agricultural Social Protection Systems (ENASP). In aggregate, ENASP represents the interests of over 12.3 million beneficiaries, who annually receive benefits from member institutions at a level of around 46.8 billion EUR [33]. In the above-mentioned countries, public support for the farmers' social insurance system is used. Three methods of support are used:

- the state supplements the farmers' contribution to the pension and disability fund in order to ensure its balance (e.g., Germany, Greece);
- some public revenues (e.g., taxes) are transferred by the state to the farmers' social insurance fund (e.g., France);
- the annual planned deficit of the fund is financed by the state through subsidies (e.g., Poland) [38].

In Poland, since 1991, the institution responsible for the farmers' social insurance system has been the Agricultural Social Insurance Fund (ASIF), created on the model of the French Mutualité Sociale Agricole (MSA) [39]. The Agricultural Social Insurance Fund (ASIF) is an institution that performs tasks related to the social insurance of farmers, members of their working households, and farm workers [40].

Social insurance systems for farmers implemented within the ASIF are based on various sources of financing, mainly subsidies from the state budget and, to a lesser extent, contributions from the insured (farmers and their household members). This is due to the fact that one of the elements of the stable functioning of social security systems (based on demographic and social conditions) is the social contract, which implies the participation of the state in financing benefits of a pension nature [41].

Public support for the farmers' pension system is based on the general assumption that farmers' social insurance should serve both agricultural and social policy objectives [35]. The main reasons for budget support for the farmers' social insurance system are the same as the reasons for state interventionism in agriculture [42]. They largely boil down to the issue of the permanent problem of income disparity between farmers and other socio-professional groups [11,12]. As a result, farmers as a group do not have the economic base, especially the income, to fully cover all the costs and expenses associated with the functioning of the agricultural social security system. There is an even stronger argument

that in many countries, including Poland, the general pension system, which performs tasks for other socio-professional groups, is also subsidised from the state budget [43]. Second, agriculture is a special area of state intervention and European Union regulation due to the functions it performs and the specific risks it poses [44]. These risks arise from the link between agricultural production and natural factors, its high vulnerability to climatic factors, the importance and peculiarity of land as a factor of production, and the strong link between the farm and the household in the dominant model of agriculture based on family farms in many countries. These characteristics define the contemporary agrarian problem [45–49], to which the response is a policy of interventionism in agriculture, including support for the social security system of farmers.

From an economic point of view, budget support for agricultural social security fulfils the objective of redistribution by shifting income from taxpayers to farmers. However, it is not only about supporting the beneficiaries of the social security system, i.e., retired farmers, by providing a source of funding for their benefits. It is also about supporting the income of active farmers who pay social security contributions. In Poland, the share of budget subsidies in the income of the ASIF pension fund (including the subsidy for farmers' health insurance) was 91–93% in 2004–2022 [40,43,50]. According to M. Podstawka [51], the degree of self-financing of the ASIF in Poland, i.e., from the contributions of insured farmers, was about 9–12% in 2004–2014. These data indicate that in order to cover the full costs of this system, farmers would have to pay 8–10 times higher premiums than they would under the conditions of a system co-financed by the state budget. The ASIF subsidy is therefore a form of income support for farmers, similar in essence to tax credits or exemptions. In the literature, such forms are referred to as tax expenditures [52,53].

In other EU countries that are part of the European Network of Agricultural Social Protection Systems (ENASP), i.e., that have separate social insurance systems for farmers, the degree of state funding of farmers' pensions varies, for example it reaches about 65% in Germany, while in France it is about 82% [54]. In Austria, the share of public funds in financing farmers' pensions will be 70.5% in 2020 [36], while in Finland it will be 77% [55].

In terms of its redistributive function, budget support for the social insurance of farmers in Poland is not only aimed at increasing farmers' incomes (through lower insurance premiums) and thus reducing income disparities between farmers and other socio-professional groups [56]. It is also aimed at reducing excessive income disparities within farm households, which is achieved through the use of progressive farm pension insurance premiums that depend on the agricultural area of the farm. Farms with an area of up to 50 converted hectares pay the lowest premium, while in the following area groups, set at intervals of 50 converted hectares, the premium is higher by the equivalent of 12% of the basic agricultural pension. The last group consists of farms with more than 300 hectares [43]. In addition, farmers engaged in non-agricultural activities pay a premium that is higher than the basic premium. In other countries joining the ENASP network, progressive social insurance premiums are also used, based on flat rates related to the estimated volume of production, the farmer's income or the area of the farm and, in the case of accident insurance, the risk group related to the type of agricultural activity [37]. Typically, farmers with lower incomes pay proportionally lower premiums, which is the case in Austria and Germany, among others [35,36].

The reason for the adequate design and support of the agricultural social insurance system is its ability to influence the transformation and structural adjustment of agriculture. It is pointed out that the development of farmers' social insurance should support the objectives of agricultural policy in ensuring generational replacement on farms, thus contributing to the maintenance and development of the economic base of agricultural insurance [57]. Demographic phenomena in rural areas, such as the lack of generational

replacement, increasing life expectancy, and the ageing of the population, are important for the functioning and economic equilibrium of the agricultural social insurance system. Through the agricultural pension scheme, the state can influence the structure of agriculture and generational change. The succession of a farm is one of the most important conditions for its survival and development [58,59]. In the process of succession, it is important to provide adequate social protection for farmers of retirement age. This would encourage intergenerational integration and provide an opportunity for successors to take over farms equipped with the skills needed in an era of rapid technological change and new challenges for agriculture. The state can use administrative and legal instruments, but also financial transfers, to provide more or less adequate retirement benefits to farmers who hand over their farms to successors. This aspect of supporting the social security system in agriculture undoubtedly has a social aspect, but it also has an impact on the development of agriculture by supporting generational change. Studies conducted in Europe, the USA, and China indicate the significant importance of the farmers' pension system in the matter of the intergenerational transfer of agricultural land. It has been proven that access to pension insurance and benefits that farmers can receive has a significant positive impact on the behaviour of older farmers in terms of transferring agricultural land (family farms) to successors [60–63].

In the literature, the issue of the farmers' social insurance system focuses mainly on two aspects, i.e.:

- the characteristics of farmers' pension and disability insurance (access criteria, insurance scope, sources of financing);
- the comparison of farmers' social insurance systems in different countries.

There is a gap in the scope of research on the assessment of the level and stability of public support for the farmers' pension system as an instrument of agricultural policy. In this context, public support takes the form of subsidies directed to agricultural producers, and at the same time secures the payment of pension and disability benefits for farmers.

3. Materials and Methods

To determine the level and changes in budget expenditure allocated in Poland to supporting the farmers' social insurance system, time series analysis methods were used, i.e., dynamics analysis (chain dynamics indices) and the trend function. The volume, real dynamics, and structure of budget expenditure on agriculture and the ASIF have been analysed, together with an indication of the relationship between these figures. The relation of these expenditures to the state budget expenditure and to the GDP of Poland was also determined.

The time frame of the analysis covers 21 years. The year 2004 was the time of Poland's accession to the European Union, and 2024 is the last year for which empirical data on budget expenditure on agriculture in Poland, including expenditure on ASIF, were available.

Budgetary expenditure on agriculture (also referred to as the Polish agricultural budget) includes [64]:

- expenditure from the national budget on agriculture, rural development and agricultural markets, including the ASIF subsidy;
- expenditure from European funds directed to agriculture and rural areas under the instruments of the first and second pillars of the CAP (included in the budget of European measures).

Pearson's linear correlation analysis was used to determine the relationship between budget expenditure on the ASIF and other national budget expenditure on agriculture and

total state budget expenditure. This method was also used to examine the relationship between the dynamics of total agricultural budget expenditures and expenditures on farmers' social insurance and the dynamics of GDP. To determine the trend of changes in total agricultural budget expenditure and ASIF expenditure in the years 2004–2024, a linear trend function was used, and its fit was assessed using the coefficient of determination R^2.

The source of the empirical material on agricultural budget expenditure in Poland was data from the Ministry of Agriculture and Rural Development (MARD) in the form of annual information on the draft state budget and the budget of European funds for agriculture, rural development, and agricultural markets. This information was the basis for the opinions on the Budget Act in the part concerning agriculture, rural development, and agricultural markets prepared by A. Czyżewski from 1998 to 2024. In addition, data from the Ministry of Finance on the implementation of the state budget and macroeconomic data from the Central Statistical Office (CSO) on GDP, inflation, and social security (cyclical CSO publications entitled Pensions, from 2009–2023) were used. The study also used open public data from ASIF and the SII for 2017–2023.

The volumes covered in the study were included in nominal values (at current prices) and real values (at constant prices). The consumer price index (CPI) was used as the deflator.

The choice of empirical research methods was determined by the type of empirical materials obtained (budget statistics data) and the length of the data time series.

4. Research Results

The average nominal expenditure for the ASIF from 2004 to 2024 is around PLN 17.5 billion, with the lowest amount in 2005 (PLN 14.5 billion) and the highest in 2024 (i.e., PLN 27.4 billion), but its nominal value exceeds PLN 20 billion only in 2023. Table 1 presents data on the nominal level (in current prices) and structure of the Polish agricultural budget during the period of Poland's EU membership, with a particular emphasis on the funds allocated to the ASIF, and with a breakdown between domestic and EU funding. It can be seen that, during the period under review, the expenditure for the ASIF almost doubled in nominal terms (from the above-mentioned PLN 14.5 billion to PLN 27.4 billion), while the expenditure for the agricultural budget almost tripled in the same period (from PLN 26.7 billion to PLN 78.1 billion), mainly due to the support from the EU resulting from the inclusion of the Polish agricultural sector in the Common Agricultural Policy since 2004. It can therefore be concluded that the economic and social components of expenditure on the agricultural sector did not grow in harmony.

Table 1. Level and structure of expenditure of the total Polish agricultural budget (national and EU funds), including subsidies to ASIF, in 2004–2024 * (at current prices).

Year	Total Agricultural Budget (in Billion PLN)	Including (in Billion PLN):		Structure of Total Agricultural Budget (in %):		
		Expenditure on ASIF	EU Funds	Expenditure on ASIF	EU Funds	National Agricultural Budget Expenditure Excluding ASIF
2004	26.7	21.3	5.4	58.5	20.0	21.5
2005	30.2	21.4	8.8	48.1	29.1	22.8
2006	34.1	23.2	10.9	43.8	32.0	24.2
2007	45.4	33.6	11.8	33.3	26.0	40.7
2008	57.2	42.3	14.9	27.6	26.1	46.3
2009	49.1	35.9	13.2	33.8	26.9	39.3
2010	50.6	29.6	21.0	31.9	41.6	26.5
2011	46.7	22.7	24.0	33.8	51.3	14.9
2012	49.7	27.4	22.3	32.0	44.8	23.2

Table 1. *Cont.*

Year	Total Agricultural Budget (in Billion PLN)	Including (in Billion PLN):		Structure of Total Agricultural Budget (in %):		
		Expenditure on ASIF	EU Funds	Expenditure on ASIF	EU Funds	National Agricultural Budget Expenditure Excluding ASIF
2013	52.5	27.4	25.1	31.4	47.7	20.9
2014	54.2	27.5	26.7	30.8	49.3	20.0
2015	55.2	26.7	28.5	31.8	51.7	16.5
2016	53.7	26.6	27.1	33.9	50.4	15.6
2017	48.4	27.6	20.8	37.0	43.0	20.0
2018	48.7	26.6	21.1	36.8	44.1	18.0
2019	47.4	26.9	20.3	37.3	42.7	19.3
2020	49.5	28.4	21.1	38.2	42.7	19.1
2021	51.2	30.1	21.1	36.9	41.3	20.6
2022	60.6	36.1	24.5	31.6	40.5	26.5
2023	72.4	47.8	24.6	27.8	34.1	32.9
2024	78.1	52.2	25.9	35.1	33.2	31.7
Average:	50.3	30.4	19.8	35.8	39.0	24.8

* assumption based on the adopted budget law for 2024. Source: data from the Ministry of Agriculture and Rural Development from 2024–2024 and [1].

It is also interesting to note the changes in the structure of the total agricultural budget as a result of the inclusion of agriculture in the support of EU funds. During the period of Poland's EU membership, European funds accounted for between 20% and almost 52% of the total Polish agricultural budget and not only became a significant supplement to domestic transfers to agriculture and rural areas, but to a large extent replaced them. The situation in this respect has changed in recent years (since 2017), since when we have observed a decreasing share of EU funds in Poland's agricultural budget in favour of domestic funds. In 2024, they will account for only 1/3 of the total of this budget, with a relatively stable share of spending on ASIF (Table 1).

Real expenditure on the ASIF (in constant 2024 prices) was highest in 2004 and 2009. (Figure 1). It can therefore be assumed that expenditure in 2024 will approach, but not yet reach, the highest levels of the period under review. Nevertheless, the amount of ASIF spending over the last eight years (2017–2024) has been successively decreasing in real terms by about 30%, taking into account the cumulative inflation rate. The decrease in the real amount of subsidies has been influenced by both economic (including the inflation rate, restrictions on the valorisation of benefits), demographic (the decreasing number of insured, by about half a million people over the past 20 years), and legal reasons. The year 2024, when ASIF expenditure will increase by almost 30% in real terms compared with the previous year, will mark the reversal of a trend that is partly justified and partly dangerous for social reasons.

The dynamics of real ASIF expenditures from 2004 to 2024 indicates that we are dealing with their relatively low volatility (Figure 2).

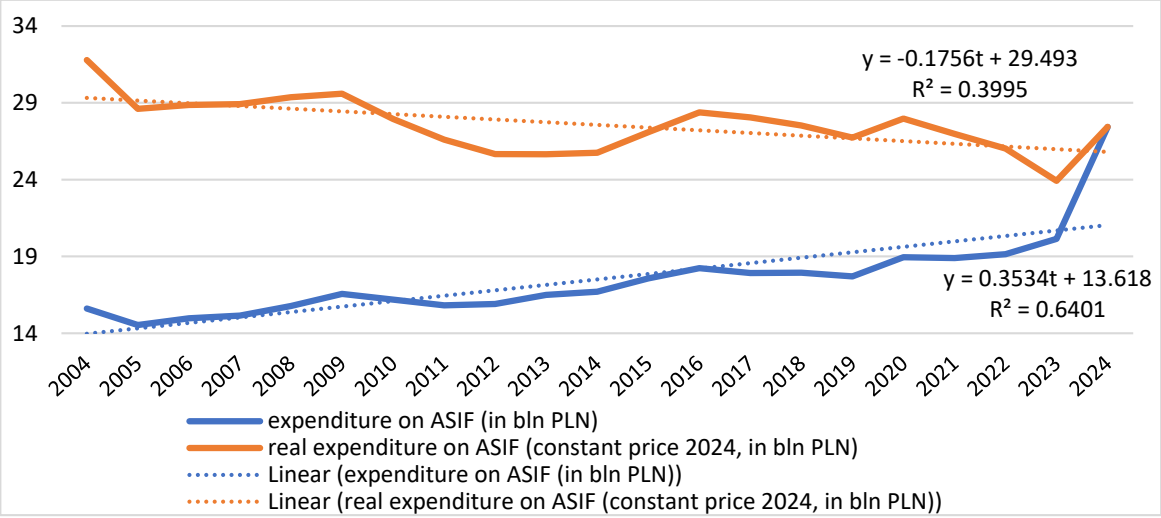

Figure 1. Nominal and real expenditure on ASIF (in PLN billion) in 2004–2024. Source: data from the Ministry of Agriculture and Rural Development from 2004–2024.

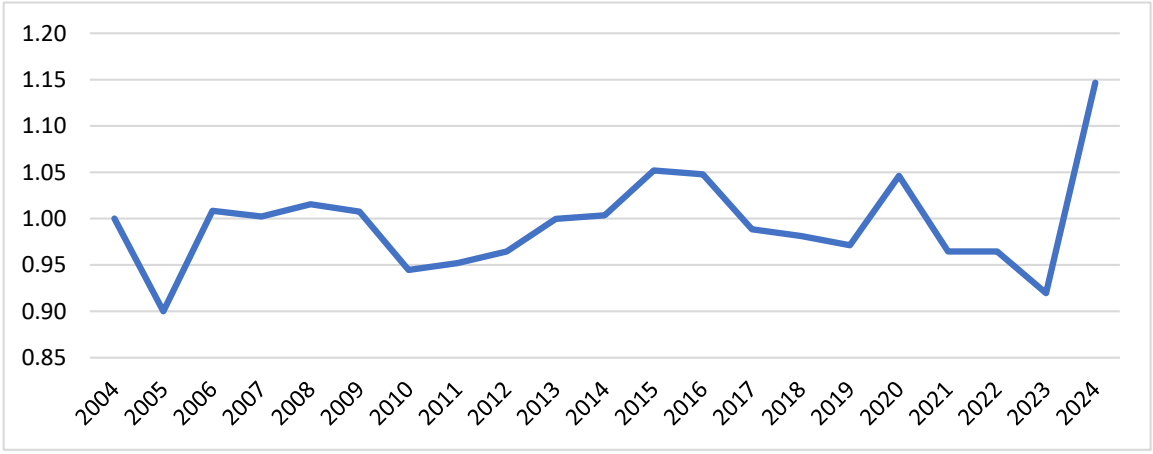

Figure 2. Dynamics of real expenditure on ASIF in 2004–2024 (year-on-year). Source: as Figure 1.

At this point, it is worth looking at demographic and social trends as they relate to the farmers' social insurance system. In the early days of the ASIF, which coincided with the transformation of the Polish economy, the average number of persons covered by the agricultural social insurance system was about 1.75 million. Legislative changes over the

years resulted in the number of insured persons falling to 1.39 million, or about 20%, over the next five years. This was due to a number of factors, including: farmers taking up additional work outside agriculture, becoming obliged to join the general insurance scheme (social security), becoming entitled to pension and invalidity benefits, and a change in the legislation allowing redundant farmers with a holding of up to two converted hectares (i.e., physical hectares adjusted for soil quality class) to receive unemployment benefits. This trend was reversed in 1996, when the number of insured persons began to increase, which was linked to the obligation to register for insurance those who started farming by buying farms from, among others, farmers receiving EU structural pensions. Other reasons include the tightening of the criteria for granting temporary agricultural disability pensions and the obligation to insure ASIF beneficiaries until they reach retirement age. It was not until after 2006 that the number of insured persons exceeded the number of ASIF beneficiaries, and this relationship continues, with a marked decrease in the numbers of both observed groups (Figure 3).

During the period under review, the real volume of expenditure on ASIF stagnates significantly and tends to decrease in the final years 2018–2023, while the number of insured persons and beneficiaries declines. However, the fact that real expenditure increases by almost a third in 2024 suggests that the level of ASIF expenditure is still strongly socially determined. It could be assumed that the main reason for the relative stability of the level of ASIF expenditure is the motive to increase the social benefits of the ASIF in order to bring them closer to the level of social security benefits in a situation of significant decline in the number of beneficiaries. Unfortunately, this is not borne out by the statistics of the CSO (Figure 4), which show that there is no convergence in the level of average pensions paid by the SII and the ASIF (the situation is similar for pensions); on the contrary, the ratio of the average SII pension to the average ASIF pension was well over 1.60 in the period under review, reaching 1.96 and 1.92 in 2021 and 2022, respectively, which means that the average SII pension was almost twice as high as the average ASIF pension. This trend changes somewhat in the following years (the ratio is 1.68 in 2024).

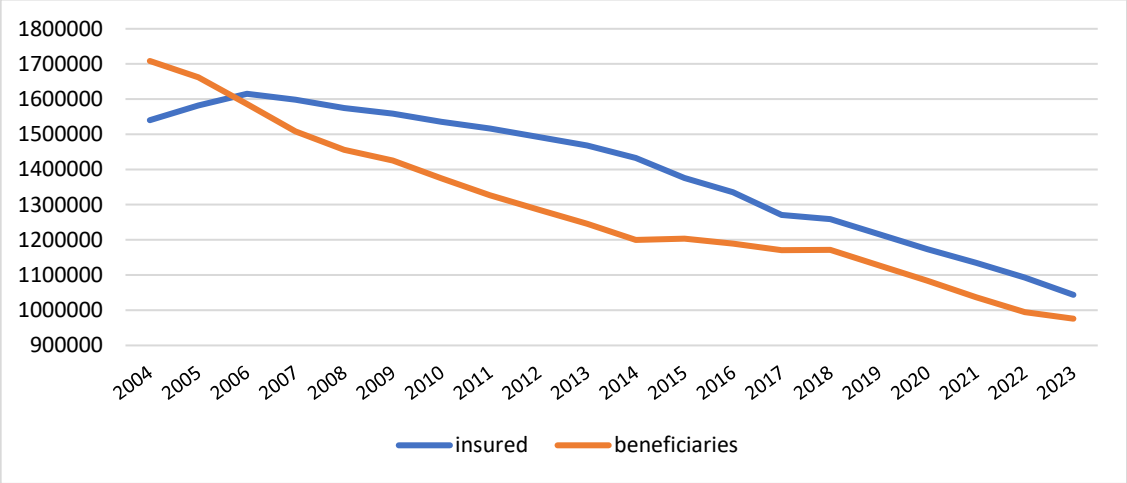

Figure 3. The number of insured people and beneficiaries in ASIF in 2004–2023. Source: ASIF data, https://www.gov.pl/web/ASIF/ASIF-w-liczbach (accessed on 25 March 2023).

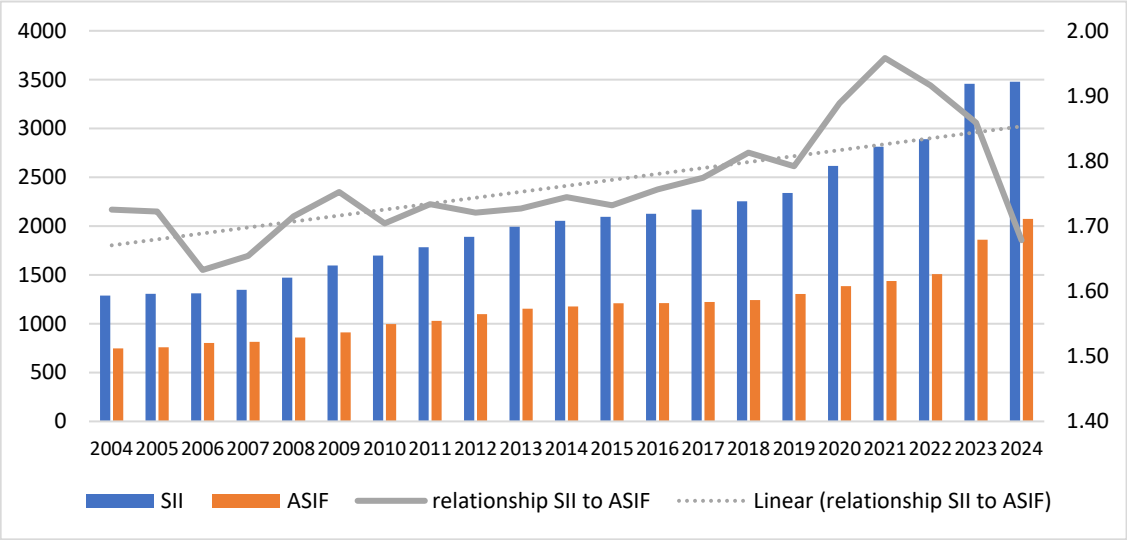

Figure 4. Average pension from the Social Insurance Institution (AII) and ASIF (current prices, in PLN) in 2004–2023. Source: own study based on Central Statistical Office data (2004–2024).

The share of domestic expenditure on agriculture, including the ASIF, in the general government budget reached its highest level in the first years of EU membership, averaging almost 12% (11.72%) until 2009, after which it gradually decreased (Figure 5). This initially high share of domestic expenditure in the agricultural sector was due to several reasons, including relatively high expenditure on the Agricultural Social Insurance Fund (ASIF), which was almost twice as high as other expenditure on agriculture and rural development, especially in the first three years of Poland's EU membership (Figure 6). This may give the impression that ASIF expenditure is excessive in relation to other agricultural expenditure. However, it should be remembered that the problem lies elsewhere—ASIF spending, although gradually 'sealed', was socially determined and could not be lower. At the same time, the development funds allocated to the agricultural sector prior to EU integration, during the period of economic transition, fell to less than 2% of the total budget expenditure, resulting in a clear marginalisation of agriculture and rural areas, which manifested itself in an avalanche of degrading effects, such as the growing civilisational gap between urban and rural areas, including the level of education of the population, and the deepening of the income gap between farmers and other socio-professional groups.

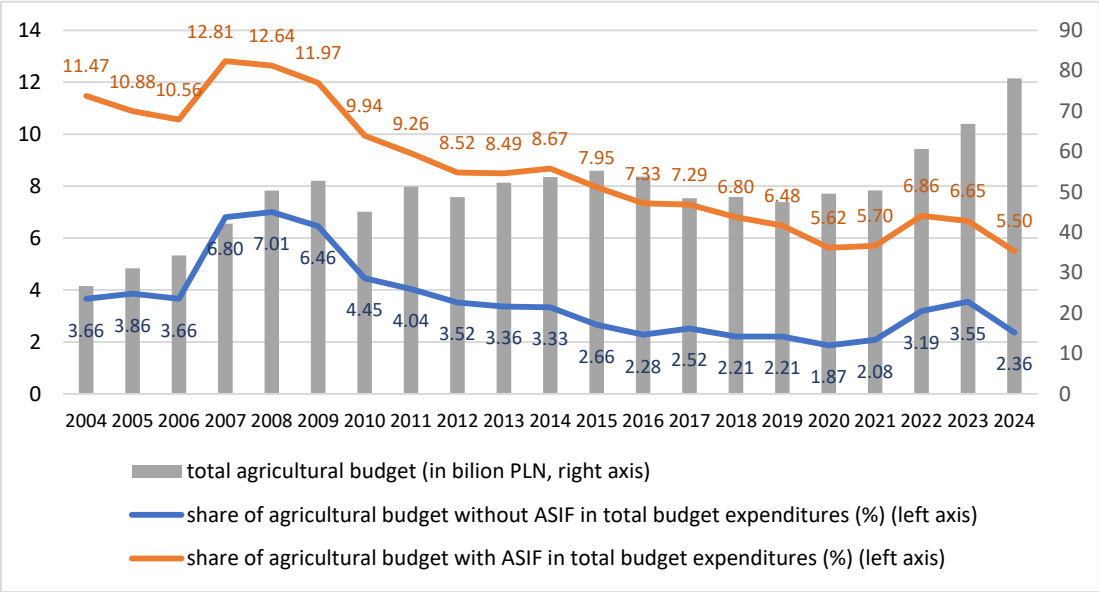

Figure 5. Share of the agricultural budget in total and without ASIF in state budget expenditure in 2004–2024. Source: as Figure 1.

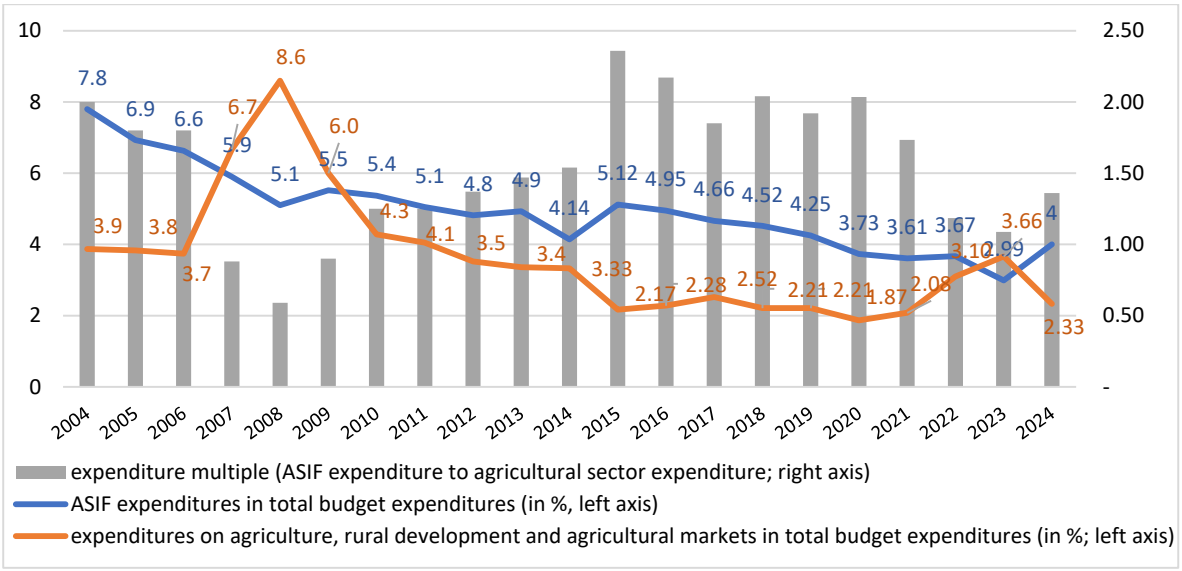

Figure 6. Share of ASIF expenditure and other domestic expenditure on the agricultural sector in the total state budget (in %) in 2004–2024. Source: as Figure 1.

The significance of ASIF expenditure in Poland's national agricultural budget is illustrated in Figure 6 (index of the multiple of ASIF expenditure in relation to the expenditure of the national agricultural budget). Changes in this index indicate the competitiveness of social and development objectives in agricultural policy. In 2024, the ratio was 1.36, compared with 1.09 the year before (Figure 6). On average, the ratio of ASIF expenditure to other national expenditure on agriculture (i.e., excluding EU funds) was 1.55 during the period under consideration. Therefore, the planned ASIF expenditure in 2024 can be considered relatively lower than the multiannual average of the ratio analysed. It should be added that the correlation of ASIF expenditure with national expenditure on agriculture, rural development, and agricultural markets remains relatively low at 0.39. The data presented in Figure 6 document a drift, and even a certain degree of trade-off, between budgetary expenditure on ASIF and strictly agricultural expenditure in the long term, regardless of the political option in power. All in all, this points to an unstable long-term

social policy towards the countryside and agriculture, implemented within the general economic policy towards this sector.

At the same time, the share of ASIF expenditure in the total government budget during the period under review was highest in the early years (almost 7.8% in 2004), only to gradually decline to less than 3% in 2023 (Figure 6).

This means that over the years considered, the ratio has fallen by more than two and a half times. It should also be noted that after an impressive more than doubling of the share of spending on agriculture, rural development, and agricultural markets in the first years of Poland's EU membership (from 3.9% in 2004 to 8.6% in 2008), which was largely due to the need for Poland to make its own contribution to CAP instruments (e.g., direct payments), it started to decline steadily to 1.87% in 2020, with an average of 2.44% over the last 10 years (2015–2024). Thus, it can be argued that the stimulation of economic functions in the Polish national agricultural budget, as opposed to social functions, has been going on continuously for more than a dozen years. In the initial period of EU membership, spending on economic functions grew faster than spending on ASIF. In 2009–2015, with a general downward trend in national agricultural budget expenditure, the ratio of ASIF expenditure to other agricultural budget expenditure showed an upward trend. In 2016–2023, however, the ratio showed a downward trend until 2024 (election year). At the same time, as shown earlier (Figure 1), the real amount of subsidies to the Agricultural Social Insurance Fund decreased. These are indications that, over the period under consideration, the socialisation of agricultural budget expenditure has been subject to a gradual reduction in favour of stimulating economic objectives in the agricultural sector.

Looking at the ratio of the Polish agricultural budget with ASIF expenditure to GDP, the downward trend in this ratio does not change until 2024. This is evidenced by the decline in this ratio from almost 3% in 2007–2008 to the lowest level of 1.18% in 2021 and to a level of about 1.3% in 2022–2024 (Figure 7). It is therefore difficult to find the characteristic of harmonious agricultural budget in relation to GDP. This is also confirmed by the analysis of the correlation between the dynamics of total agricultural budget expenditure and the dynamics of GDP (in current prices), which is positive but low (Pearson's correlation coefficient r_{xy} is 0.44). Moreover, there is no statistically significant correlation between the dynamics of budget expenditure on ASIF and the dynamics of GDP.

This provides another premise for the thesis that the agricultural sector in Poland has not benefited proportionally, i.e., in a balanced way, from the effects of GDP growth through budget spending. Without the financial support from the budget of the European funds, the sectoral disparities in the distribution of resources from national income would have become even more pronounced. However, the magnitude of the reduction in this share is too large and disproportionate to the effects of real GDP growth, which has been in the range of 3.5–4% for a long time and will also be positive in 2023–2024, although much lower than in previous years (2%).

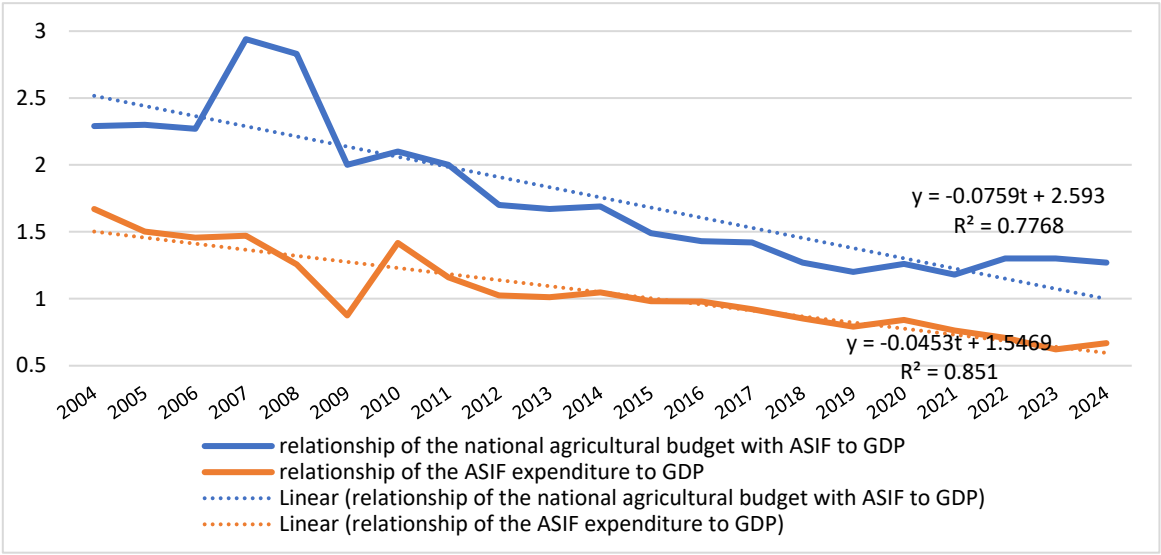

Figure 7. National expenditure on the agricultural sector, including ASIF, in relation to GDP (in %), 2004–2024. Source: as Figure 1.

5. Discussion

The very low degree of self-financing of the agricultural pension system in Poland and the resulting financing of more than 90% of its expenses from budget subsidies have led to its recognition as one of the forms of agricultural support [65,66]. However, budget expenditure to support the farmers' social insurance system not only pursues social objectives by providing funds for the payment of agricultural pensions, but also supports certain redistributive objectives of agricultural policy. In fact, subsidies to the agricultural social security system are a form of fiscal preference [38,44]. However, their importance in achieving the above-mentioned objectives is determined by the actual amount of funds allocated to support the farmers' pension fund, and thus by the extent of the reduction in the social security burden on agricultural producers.

Payments to the farmers' social insurance system are a form of specific subsidies directed to the agricultural sector. In this context, this study fits into the research conducted in European Union countries on the redistribution of agricultural subsidies and their role in supporting the economic efficiency of farms [67–69], the stability of farmers' income [70,71], and the perpetuation of family farms [61,72].

The level of subsidies to the agricultural pension fund in relation to GDP varies from country to country. A study by Giday and Tatay [38] shows that, in the EU countries, the highest level of subsidies in 2021 was in France (0.92%), Spain (0.63%), and Poland (0.75%). However, as this study shows for Poland, this ratio is gradually decreasing.

It should be noted that economic prosperity has a strong impact on agricultural income. On the one hand, in periods of economic downturn, social benefits become an important element of the income of the farming family, which legitimises the redistributive function of the budget through the ASIF subsidy; on the other hand, in the recovery phase, the question arises as to how far farms consume the effects of this growth in relation to other social groups. Unfortunately, the answer to this question is not in favour of the agricultural sector due to its disadvantage in this respect, as mentioned in many other studies [29,30,50].

It should be noted that budget expenditure on the ASIF has a redistributive function in terms of farmers' income, but more so for those farmers and their families who have small and very small farms. This is due to the progressive mechanism of the burden of pension insurance premiums on farmers described above. Therefore, in most cases, the subsidy to the farmers' social insurance system is treated as an element of social expen-

diture within the framework of agricultural policy instruments [1]. These expenditures within the agricultural budgets are in constant competition with the funds allocated for agricultural and farm development purposes, such as those related to their restructuring and modernisation. However, the importance of public support to the social insurance system for farmers should not be overlooked as a fiscal instrument for active farmers and a form of influence on generational change in agriculture [60,63,73].

The level of subsidies to the agricultural social insurance system largely determines the possibility of reducing the disparity between agricultural pensions, i.e., bringing the level of these benefits closer to that of non-agricultural (labour) pensions and annuities, which in Poland are almost twice as high as agricultural pensions. In a broader sense, the level of the budget subsidy to the ASIF is a factor in shaping the relationship between the economic and social objectives of the expenditure of the agricultural social security system. However, it should be emphasised that the farmers' social insurance system needs to assume the lack of insurance cover in the amount of the premium due to the cumulative effect of the disparity of real agricultural incomes under market conditions in the past period [30,50,74,75]. At the same time, we are aware that the effective protection, as well as the improvement in the level of pensions and farmers' rent, is determined by the joint impact of social and agricultural policies [2]. At present, it definitely depends more on the amount of the state budget subsidy to the pension fund (the social component of the ASIF) than on the contributory financing (the economic component of the ASIF), apart from the obvious need to increase the efficiency of the expenditure incurred.

6. Conclusions

The data presented above and the analyses carried out on the basis of them indicate that:

- during the period under review, ASIF expenditure almost doubled in nominal terms, while agricultural budget expenditure tripled. This was mainly due to the inclusion of the Polish agricultural sector in the Common Agricultural Policy and the continuous support included in the agricultural budget. It can therefore be concluded that the economic and social components of agricultural expenditure have not grown in a balanced, i.e., harmonious, way;
- the level of ASIF spending has strongly influenced the level of overall spending on the agricultural sector, significantly increasing it, which was particularly noticeable in the first three years of Poland's EU membership, when spending on social insurance for farmers and their families in the national agricultural budget was almost twice as high as development spending, i.e., spending on agriculture, rural development, and agricultural markets. In the following years, the share of ASIF subsidies in the total agricultural budget decreased, ranging from 27.6% to 38.2%. ASIF expenditure, on the other hand, showed a clear downward trend in relation to total government expenditure (from less than 8% in 2004 to less than 3% in 2023) and in relation to GDP (from 1.76% to 0.67%);
- real expenditure on the ASIF was highest in the early years of Poland's integration into the EU (2004 and 2009). At the same time, it should be noted that the amount of this expenditure gradually decreased over the period under consideration, reaching a level in real terms (taking into account cumulative inflation) in 2023 that is 24.8% lower than in 2004 (in 2024, the difference is 13.8% lower than in 2004). The reasons for this situation are economic, demographic, and legal. In 2024, expenditure on the ASIF increased significantly compared to the previous year, but this was an election year and the question remains as to how much of this is a permanent change in a trend that has been observed for years;

- the real decrease in ASIF subsidies is part of a general trend of decreasing agricultural budget expenditure in Poland relative to GDP (by almost 60% compared to the first years of Poland's EU membership). Thus, it can be concluded that the agricultural sector in Poland has not benefited proportionately from the effects of GDP growth through budget expenditure, and the accumulation of the disproportion between the dynamics of these figures would have been much greater had it not been for the significant support for agricultural spending in Poland from the budget of European funds.

The downward trend in the real amount of subsidies to the ASIF and its ratio to state budget expenditure and to GDP testifies to the declining role of this fiscal instrument in the agricultural policy implemented by successive governments in Poland. At the same time, the volatility of the share of ASIF subsidies in the structure of the agricultural budget, with a general downward trend since 2015, testifies on the one hand to the great instability of agricultural policy priorities, and on the other hand to the fact that the economic objectives of this policy have gained the upper hand over redistributive and social objectives in recent years.

In the long term, ensuring relative stability or a slight increase in real expenditure on insurance for farmers and their families (in the form of subsidies to the ASIF) and, on the other hand, a decline in the number of ASIF beneficiaries for demographic and economic reasons, create the conditions for a more pronounced increase in the average level of ASIF benefits. The aim is to reduce the considerable disparity between the average agricultural pension and the average employee pension (from the Social Security Institution).

Agriculture is characterised by low profitability and dependence on support systems. If a farmer with an average level of productive and technological resources can only achieve a low income, he usually has two different alternatives. One is to switch to intensive production methods, and the other is to stop farming. Both alternatives are unfavourable in terms of agricultural sustainability. It is therefore important to use agricultural policy instruments properly to encourage farmers to continue agricultural production, taking into account natural, climatic, and social needs. This requires, however, that agricultural incomes be supported at a level comparable to that of other socio-professional groups. It is also necessary to support generational change, which is a prerequisite for the sustainability of family farms and an accelerator for their potential for progress and innovation. An important, even indispensable role in these processes can be played by a well-designed, stable social security system for farmers. Government action in this area, including subsidies and appropriate regulation, is an important instrument of agricultural policy, not only in its social but also in its economic aspect. In conclusion, it is hoped that this study will inspire similar studies in countries with similar economic conditions to Poland regarding the level and dynamics of social insurance in agriculture and non-agriculture. There is a chance that this will have positive practical effects.

The limitation of this study was the inability to determine the impact of budget subsidies directed to support farmers' social insurance on the income of agricultural producers as a result of lower contributions to the ASIF (assuming full financing of the system by the insured). In particular, it would be important to determine such a relationship for different area groups of farms. This requires microeconomic research based on agricultural accounting data. This is a challenge for future research.

Future research should also focus on analysing the effectiveness of public support for the farmers' social insurance system as an instrument of agricultural policy implementing redistributive and pro-development goals. It is also important to seek an answer to the question of to what extent subsidising farmers' pensions promotes generational changes in the countryside and thus strengthens the processes of sustainable development of agriculture based on family farms.

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