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Green and Reserve Logistics of Packaging and Plastic Packaging Waste under the Conditions of Circular Economy at the Level of the European Union Member States

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Abstract: Sustainable development involves constant efforts to reduce pollution by using resources as efficiently as possible. One of the sources of pollution is waste from packaging, recovery, and of course, the possibility of recycling them. The research theme of this paper is the reverse logistics of plastic packaging, which allows the realization of the idea of circular economy and green logistics, which promotes the idea of sustainable development. The EU is strongly committed to issues related to the management of plastic packaging and waste to reduce environmental pollution and achieve circularity goals. Through this article, we aim to highlight the degree to which the EU member states are included in the plastic packaging recycling targets for the year 2030. To highlight the evolution trend for the recycling rate of plastic packaging, we used an advanced forecasting model that runs a series of variables in order to draw up a forecast as accurate as possible. After highlighting the recycling rates for plastic packaging at the level of the EU member states, we proceeded to outline some recommendations in order to encourage the EU member states to make the recycling process more efficient. The current study continues the series of studies dealing with the problem of recycling, but it covers a topic not addressed until this moment, namely the behavior of the citizen regarding the recycling activity seen through the prism of national culture. The current study aims to strengthen the specialized literature in this field and to offer innovative solutions that appeal to the respective national cultures regarding the availability of the populations of the EU member states to address the problem of recycling plastic packaging, not only from a legislative perspective but also from a cultural one. In conclusion, this study generates a model of approach to government policies regarding the recycling of plastic packaging considering the types of national cultures prevailing in the EU member countries, with this being possible by grouping the countries into culturally homogenous clusters. In this way, the environmental policies enunciated by governments can be adapted to convey the message in a more personal way, considering the cultural differences between the EU member states.

Keywords: packaging and plastic waste; reverse logistics; green logistics; circular economy; recycling rate; national culture; Prophet model; sustainable development goals; social impacts; climate change

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1. Introduction

In recent years, the concept of sustainability has captured the attention of researchers, being an intensely debated theme in specialized works and also a central theme in government regulations.. Among the three pillars of sustainability (environmental, economic and social), the environmental component is the most intensively debated and aims at the aspects regarding the protection of the natural environment, the more careful use of natural resources, the reduction in the carbon footprint, and the production of environmentally friendly and easy-to-use recycled packaging. Reducing the negative effects of economic growth on the environment requires a new model of sustainable consumption and production [1]. Thus, the migration from the linear economy to the circular economy and the

transformation of waste into resources has become a necessary approach in this process [2]. The MacArthur Foundation [3] states that plastic and its derivatives, such as packaging, are one of the priority issues for the circular economy. Plastics are essential to the modern economy, even though they can cause significant damage to the environment. However, only 14% of all plastic packaging is collected for recycling after use, and large amounts end up in the environment [3].

The growth of the population, but also the development of the branches of the economy as much as possible, have over time remarkably influenced the production of packaging, and in particular, of plastic [4]. Even if society embraced the development of industries, and implicitly economic growth, the exponential increase in the number of plastic products was ignored [5]. Global plastic production has grown exponentially, from 1.5 million tons in 1950 to 322 million tons in 2015 [6]. The customs of today's society have frequently imposed the use of plastic packaging so that their spread is inevitable in today's society [7]. The plastics industry is an important industry for the European economy and increasing its sustainability can generate new opportunities for innovation, competitiveness, and job creation [8]. Packaging is the most important use of plastic in the EU. It accounts for approximately 40% of plastic production and is responsible for 61% of all plastic waste generated [9]. Plastic packaging also has the lowest reported recycling rate in the EU (42%), compared to other materials, such as paper and cardboard packaging (83%), glass (73%), and metals (76%) [10]. In this regard, the European Commission adopted Directive (EU) 2018/852 on packaging and packaging waste [11], which sets the new plastic packaging recycling targets for 2025 (50%) and 2030 (55%). Many entrepreneurs see the need for more decisive action to prevent the generation of plastic waste as a business opportunity. More and more new businesses are emerging that provide circular solutions, such as reverse logistics for packaging or alternatives to single-use plastics. Logistics plays a vital role in a country's economic growth and greatly increases air pollution, including greenhouse gases [12].

However, previous green logistics research focusing on plastic packaging issues is scarce despite the impact it has on the environment. Given the need to reduce the impact of plastic packaging on the environment, this study addresses the issue of recycling it to help improve the environmental performance of green logistics.

The objective of the research is to verify the inclusion of the EU member states in the targets set by the European Commission regarding the recycling of plastic packaging, starting from the premise that plastic is the biggest source of pollution among all types of packaging. This verification was performed by estimating the plastic packaging recycling rate using the Prophet model based on three sets of indicators from the Eurostat database, which trained the model. The obtained results were used to form clusters according to the national culture with the help of Hofstede's model. Although the research tools used in this work exist, they have never been connected in order to generate research on the problem of recycling plastic packaging. Thus, although forecasting models are used in various research studies to highlight future phenomena, they have not been used to deal with the problem of plastic packaging recycling. Moreover, the Prophet model, based on which the forecast for the recycling rate is made, combines two other variables besides the recycling rate of plastic packaging, variables that impact the evolution of the recycling rate. The current studies deal with the problem of recycling technically, considering a series of methods to transform the plastic or to eliminate it through chemical processes that can also be harmful to the environment. As such, the social side is neglected, although the attitude of the inhabitants of a country can significantly impact the evolution of the plastic packaging recycling rate. Any environmental policy must take into account the cultural typology that characterizes a state in order to be able to formulate rules, norms, and laws regarding the protection of the environment that generate positive reactions at a conscious level. As such, the current study aims to unify the elements of forecasting, generated by the Prophet model, with the elements of national culture, as highlighted in Hofstede's study, to create a unique study that appeals to the mentality traits and typology of the cultures of

those involved. The plastic problem is not a new, recent problem, but it remains a current problem. Various methods and strategies have been drawn up and implemented, yet the outcomes are not encouraging when considering the current data on pollution, climate change, etc. Thus, the identification of countries with problems in achieving the objectives of Directive 2018/852 regarding the recycling of plastic packaging for the years 2025 and 2030 with the help of an advanced forecasting program such as Prophet, as well as the reporting of environmental policies to a culturally appropriate scenario for the countries involved in the research, represents an innovative approach and modeling of people's behavior. The most important and powerful organizations in the world (Marriot, IBM, HP, etc.) appealed to organizational culture in the formulation of objectives, strategies, norms, and values that correspond to the existing organizational climate, so now it is the turn of the governments to appeal to the national culture in the formulation of norms and rules in accordance with the cultural type specific to the respective area. Also, with the support of the national culture, the recycling objectives formulated at the European level can be presented so that the environmental problems gain resonance in the spirit of the citizens and are no longer treated as a civic obligation and rather as a moral obligation.

This research is structured as follows: the Introduction is followed by the section intended to address the specialized literature related to the research topic. The second section presents the processing of the indicators used in the research, from the Eurostat data source, using the Prophet model. The third section refers to the results and discussion regarding the researched topic, and the conclusions complete the analysis through a synthesis of the main contributions made, as well as the limitations of the present research.

The literature review section presents the theoretical support considered in this approach, as well as the research questions that we propose to test in this paper.

2. Theoretical Background and Research Questions

The concept of sustainability aims to identify a type of waste management that is as sustainable as possible to eliminate the problem of pollution. In terms of consumption, reuse and recycling are imperative pillars of resistance for sustainable development. Therefore, transition to a circular economy and the awareness of the population about the limits of the planet are important topics in society nowadays. The circular economy is a necessity for sustainable development and the only way to delimit economic growth from the consumption of natural resources and the generation of waste. This theme represents an innovative approach, which emphasizes the valorization of materials in the most efficient manner so that the life cycle of the material is extended as much as possible [13]. Governmental legislation forces manufacturers to manage products that are nearing the end of their life as prudently as possible, relying more and more on the development of the circular economy [14]. However, in order to dispose of the new categories of raw materials from waste, a sustained effort is needed from the producers, as well as the consumers. The economic and social environments, as well as the environment, are negatively affected by the growing amount of waste generated, so waste management policies are crucial in order to reduce greenhouse gas (GHG) emissions [15]. Globalization and industrialization have led to significant environmental pollution, and encouraging activities to reuse and recycle materials helps move towards a circular economy [16]. In other words, the circular economy uses resources from recycling and reuse and minimizes the amount of waste [17]. Thus, the new closed-loop model will reduce environmental impact and produce economic growth. But the environmental impact also comes from other areas of economic activity, such as logistics [18].

In this context, what makes the correlation between the environmental pillar of sustainability and the circular economy is Green Supply Chain Management. In fact, to achieve a circular economy model that emphasizes environmental protection and resource conservation, it is necessary to implement Green Supply Chain Management [19]. Within the Green Supply Chain Management concept, the practice of green logistics is the main trend of modern logistics and the condition for the development of the circular economy

because Reverse Logistics is the basis for closing the economic cycle and reducing gas emissions [19]. Reverse logistics represents a process of planning and implementing a flow of raw materials, stocks, and also finished products, with the aim of recovering their value and of their elimination through environmentally friendly methods [20].

If in the past, supply chains focused on logistics flows starting from the procurement of raw materials to the realization of finished products, today, the global market and sustainable development require new models of supply chains. In this context, the introduction of the concept of Green Supply Chain Management is absolutely necessary to achieve the connection between sustainability and the circular economy. In recent years, in the context of the sustainable management of resources, a new trend in logistics has been observed, that of reverse logistics, for which there are synonymous terms such as environmentalism, logistics in the field of recycling, or waste logistics. Waste management issues are increasingly entering the field of logistics, which enhances the importance of reverse logistics. The elimination of waste can be stimulated by logistics and especially by reverse logistics, which is part of traditional logistics and represents the ecological orientation of logistics and is therefore necessary for sustainable development. Reverse logistics allows the realization of the idea of a circular economy by significantly reducing the entropy of the modern economy while increasing the recycling rate of the resources used [21]. Green, low-carbon development models are widely accepted and implemented in logistics operations [22]. In traditional logistics, a more circular and greener production system is linked to the implementation of green logistics, which aims to reduce greenhouse gas emissions, use natural resources, and return materials at the end of their life cycle [23]. Basically, these activities are components of reverse logistics and green logistics. Grouping these activities into the two concepts is very difficult because reverse logistics and green logistics overlap in the areas of recycling, remanufacturing, and reuse of packaging, while reducing packaging and emissions and minimizing environmental impact are only parts of green logistics [20]. The main goal is to reduce environmental impact, minimize production costs, and improve product value [24].

Green and sustainable logistics is the planning, control, management, and implementation of a logistics system using advanced environmental logistics technologies [25]. The main goal of green logistics is to eliminate environmental damage caused by logistics activities. Green logistics aims to achieve a sustainable balance between economic, social, and environmental objectives [26]. Logistics plays a vital role in the economic development of a country and causes environmental pollution through its most famous activity—transport. An important approach to green logistics, in this sense, is the use of alternative energy sources, the attempt to use alternative fuels to totally or partially replace the use of fossil fuels [27]. As such, in order to promote the circular economy, it is necessary to create, implement and exercise control with regard to a performing reverse logistics system. Without reverse logistics, a sustainable circular economy cannot be implemented. This promotes the creation of a system at the organization level with the help of which environmental problems can be mitigated with the help of procedures designed to ensure the sustainability of the actions undertaken. In recent years, there has been a significant increase in interest in the reverse logistics of plastic packaging in support of the various forms of recovery, reuse, regeneration, and recycling required by the principles of the circular economy.

Packaging is one of the main users of virgin materials as 40% of plastics and 50% of paper used in the EU are for packaging. Without action, the EU would see a further 19% increase in packaging waste by 2030 and for plastic packaging waste even a 46% increase, as stated by the European Commission. Plastics are the dominant materials of our modern economy and without action, their production is expected to double in the next two decades. However, only 14% of all plastic packaging is collected for recycling after use, and large amounts end up in the environment [3]. Plastic recycling implies a series of benefits, including the production of virgin plastic materials or the reduction in carbon emissions [28,29]. Prevention and innovation are the key factors for reducing packaging waste at source and minimizing the environmental impact of packaging throughout its life

cycle. The plastic generated in the production processes is extremely harmful, being in most cases a threat to the environment through the infiltration of particles into the water table.

Reverse logistics in the management of plastic packaging meets the requirements of Directive (EU) 2018/852 on packaging and packaging waste [11], setting new plastic packaging recycling targets for 2025 (50%) and 2030 (55%). On average, each European citizen was responsible for 35.9 kg of plastic packaging waste in 2021 according to the European Commission Report, and of this, 14.2 kg was recycled. However, the European Environment Agency notes that the EU still lacks the capacity to reuse, recycle, and recover all plastic waste and is therefore looking for export opportunities. But recycling plastic packaging waste in countries outside the EU often generates increased pressures on the environment in terms of pollution, CO_2 emissions, and the dispersion of plastics in the environment compared to treatment or recycling in the EU [30]. Recently, a new regulation took shape and is coming to meet the problems of recycling rates, imposing a new set of objectives. Regulation 2022/0396 COD is a proposal for a regulation on packaging and packaging waste that was submitted by the European Commission in November 2022. It is currently making its way through the ordinary legislative procedure (COD) of the EU. Regulation 2022/0396 COD proposes ambitious objectives for the recycling of plastic packaging, with significant increases compared to the stability objectives of Directive 2018/852. Regulation 2022/0396 COD maintains the ambitious objectives for the recycling of plastic packaging established by Directive 2018/852 (for plastic 50% by 2025 and 55% by 2030) and proposes new objectives for January 2035 and January 2040. In addition to the recycling objectives, Regulation 2022/0396 COD also introduces a series of other measures to reduce packaging waste plastic, such as limiting the use of single-use plastic packaging, introducing additional requirements for the design of plastic packaging to make it easier to recycle, as well as increased obligations for manufacturers to use recycled materials in plastic packaging [11].

The challenges related to the production, consumption, and end of life of plastics can be turned into an opportunity for the EU and for the competitiveness of European industry. Through the concrete actions designed, the EU can turn the vision for a more circular economy of plastics into reality. The specialized literature abounds in studies aimed at reverse logistics in all areas of the economy [31–36], but the cultural component must also be considered in terms of the behavior of the population. An important aspect that must be analyzed refers to the behavior of the consumer of plastic packaging, as the recycling activity is closely related to their attitude towards the environment. The term culture is presented as an abstract notion, but one which generates effects in every field of activity. The types of culture recognized in the specialized literature refer to national, organizational, professional, and individual cultures [37]. Although there are several studies that level the construction of national culture, Hofstede's study, which focuses on the six cultural dimensions at the national level, is the most representative. He considers that the national culture is essential in the socialization process since childhood, since values and beliefs are stored in that period [38]. Thus, a series of studies refer to the problem of consumer behavior regarding the waste recycling rate, but none correlates with the cultural dimensions stated by Hofstede.

Considering the information noted in the literature review section, as well as the acute need to find solutions regarding the mobilization of societies to increase the plastic recycling rate, we formulated three research questions around which the case study was built.

Research question No. 1.

Considering the plastic packaging recycling objectives for the year 2030, will there be EU member states able to reach the recycling rate of 55% by the year 2030?

Research question No 2.

Considering the six cultural dimensions stated by Hofstede, can the EU member states be put together into groups that share common beliefs and values?

Research question No 3.

In case the member states fail to reach the indicators provided for the year 2030, can we identify an increase in the recycling rate of plastic packaging or a stagnation for the EU member states?

3. Research Methodology

3.1. Explaining the Prophet Model

Prophet is an IT system that can be used to forecast data starting from an additive model. It can integrate seasonal oscillations such as daily, weekly, or annual seasonality. At the same time, it also integrates the effects generated by holidays that can impact the forecasts of some data. For this reason, Prophet is more often used for querying time series with strong seasonal effects. The Prophet software 1.0 was launched in 2017 by the Core Data Science team on Facebook.

This forecasting system distinguishes itself from other forecasting methods by its flexibility and precision, being very popular in many fields, especially in the E-commerce field, where supply is mainly based on the data provided by this software. Prophet is a mathematical model that makes forecasts based on an algorithm. It can be used in any field, having a remarkable precision. The algorithm on which Prophet is based is scalable and precise, being applicable even at the level of meteorological model forecasts. Thus, it models a package of components, including data belonging to a chronological series, adding trends, seasonality index, and noise [39–42]. These components are rendered in the following form:

$$y(t) = g(t) + s(t) + h(t) + e(t)$$

where:

y(t)—the value of the series at time t;
g(t)—trend component;
s(t)—seasonal component;
h(t)—the effects generated by the holidays;
e(t)—the error term.

3.2. Data Selection

To forecast the recycling rate of plastic packaging for the 2022–2030 timeframe, we selected Eurostat data for the indicators recycling_rate, waste_generation_kg_per_capita rate, and waste recovery rate. The data selected and processed with the help of the Prophet model are from the time interval 2009–2021 so that the analyzed time horizon is a consistent one, providing a solid basis for processing. The three indicators under analysis are closely interdependent, so the waste generation rate will directly influence their recovery rate, the latter having direct effects on the recycling rate.

The selected data are characterized by accuracy and precision, Eurostat being a clear and eloquent source in the presentation of such information, and their processing with the help of the Prophet model offers a capitalization of these data by creating a set of predictions based on a conclusive and tested algorithm.

3.3. Explaining Hofstede's Model

The model proposed by Hofstede presents national cultures from the perspective of six dimensions: power distance intensity, masculinity vs. femininity, uncertainty avoidance, long-term orientation vs. short-term orientation, indulgence vs. restraint, and individualism vs. collectivism [38]. Geert Hofstede developed a questionnaire that included 30 questions to identify the values that characterize the type of culture at the level of a country. As such, the questionnaire includes 24 content questions, allowing the calculation of scores on each dimension separately as follows: six cultural dimensions × four questions/dimensions = 24 content questions. To these 24 questions, another 6 identification questions referring to the respondent's sex, age, level of education, etc., are added. By pro-

cessing the obtained data, it was noted that the nationality of the respondents influenced the content questions within which an analysis model could be identified. Thus, the variation in the obtained scores demonstrates "a significant country effect". As mentioned, the results obtained as a result of scoring the answers for the 24 content questions create the existence of six cultural dimensions that characterize national cultures. The content questions receive between 1 and 5 points, so a standard statistical program calculates the average scores on five-point scales, thus generating a cultural profile for each individual country.

The reliability of the Value Survey Model (VSM) is demonstrated by validating the obtained scores. For example, the IBM database [43] calculates Cronbach's alpha index for four dimensions at the level of 40 countries, obtaining a score of over 700 in order to test the reliability of the test [44].

Power distance index (three items): Alpha = 0.842

Individualism index (six items): Alpha = 0.770

Masculinity index (eight items): Alpha = 0.760

Uncertainty avoidance index (three items): Alpha = 0.715

3.4. Data Selection

In order to identify the predominant type of culture at the national level, we proceeded to retrieve the data on six dimensions for the EU member countries, with the aim of creating clusters of countries, homogeneous from a cultural point of view, starting from the premise that countries governed by influential similar cultures will be able to collaborate and communicate effectively in the formulation of strategies, plans, projects, or simply to find a common communication model in order to achieve some objectives set at the EU level. The data were taken from the official website of the researcher Geert Hofstede; they are public and can be used free of charge for scientific processing. The variables investigated in this work are presented in Table 1.

Table 1. Indicators used in this research.

Variable	Data Sets	Measures	References
Recycle rate	EU states recycle rate plastic 2009–2021	Percentage	Eurostat [45]
Recovery rate	EU states recovery rate 2009–2021	Percentage	Eurostat [46]
Waste generation	EU states waste_generation_kg_per_capita 2009–2021	kg_per_capita	Eurostat [47]
Cultural dimensions	EU states—6 cultural dimensions according to Hofstede	Points	VSM Manual [44]

Source: own design based on Eurostat and VSM from Hofstede.

In order to answer research question number 2, we proceeded to create some clusters with the help of the SPSS program. After entering the data regarding the six cultural dimensions, we used the Center Distance Method/Hierarchical Cluster button and set the Euclidian distance for continuous data.

4. Results

Considering the recycling rates for plastic packaging for the EU member states for the period 2009–2021, we proceeded to run the information in order to forecast the recycling rates of plastic packaging for the period 2022–2030 with the aim of identifying the countries which will achieve the objectives for the year 2030 (Table 2). According to Directive (EU) 2018/852 on packaging and packaging waste [11], the recycling rate set for plastic packaging is 50% for the year 2025 and 55% for the year 2030. The data presented with

** represent the countries that, according to estimates, will manage to reach the objectives set for the years 2025 and 2030, and the countries marked with * are the countries that, although they will not reach the established objectives, will approach these thresholds, having a huge potential in reaching the objectives imposed.

Table 2. Estimates of the recycling rate of plastic packaging at the level of the European Union member states for the period 2022–2030 (percentages).

Country	2022	2023	2024	2025	2026	2027	2028	2029	2030
Austria	33.83	35.99	38.80	30.18	31.70	33.86	36.67	28.05	29.57
Belgium	46.70	46.47	45.96	49.92 *	49.97	49.75	49.24	53.19	53.25 *
Bulgaria	42.67	35.89	57.98	55.02 *	48.57	43.76	60.04	58.13	56.33 **
Croatia	34.23	34.26	34.32	34.19	34.21	34.25	34.31	34.18	34.20
Cyprus	45.49	41.14	35.51	49.54 *	46.49	42.15	36.51	50.55	47.50
Czechia	44.36	40.54	36.11	44.30	41.10	37.28	32.85	41.04	37.84
Denmark	36.17	41.39	47.02	41.52	46.33	51.54	57.17	51.68	56.48 **
Estonia	36.70	33.00	28.70	38.63	35.53	31.83	27.53	37.47	34.37
Finland	46.27	46.75	46.46	55.31 **	56.56	57.03	56.74	65.60	66.84 **
France	22.56	21.56	20.34	24.44	23.68	22.68	21.46	25.57	24.80
Germany	51.45	53.81	57.28	41.95	43.20	45.56	49.03	33.70	34.95
Greece	31.02	26.41	45.20	40.15	40.70	31.92	53.12	50.75	43.21
Hungary	31.87	29.11	23.75	39.69	37.23	35.98	25.21	47.77	42.83
Iceland	33.88	36.72	40.07	29.30	31.61	34.44	37.79	27.02	29.33
Ireland	27.42	28.74	30.27	27.41	28.52	29.85	31.38	28.51	29.63
Italy	57.18	60.38	63.48	65.78 **	69.08	72.28	75.38	77.68	80.98 **
Latvia	40.32	41.76	42.92	50.27 **	52.01	53.45	54.60	61.96	63.69 **
Lithuania	42.50	44.33	46.34	48.10 *	49.73	51.56	53.57	55.33	56.96 **
Luxembourg	41.67	43.73	46.25	40.11	41.69	43.75	46.26	40.13	41.71
Malta	20.07	19.73	19.26	20.36	20.13	19.78	19.31	20.42	20.18
Netherlands	48.07	43.54	37.38	56.43 **	53.55	49.03	42.86	61.91	59.04 **
Norway	32.49	36.99	42.69	28.40	31.67	36.16	41.86	27.57	30.84
Poland	35.68	30.85	26.12	43.78	40.34	37.52	31.29	53.87	47.92
Portugal	36.59	37.35	37.59	47.37 *	48.65	49.41	49.65	59.43	60.71 **
Romania	39.93	35.49	30.10	41.20	37.72	33.28	27.89	38.99	35.51
Slovakia	66.25	68.31	70.60	66.13 **	67.96	70.02	72.31	67.84	69.67 **
Slovenia	35.00	34.03	33.97	30.01	28.11	27.13	27.07	23.12	21.22
Spain	53.51	53.98	54.15	62.17 **	62.95	63.42	63.59	71.61	72.39 **
Sweden	46.12	42.01	38.92	54.31 **	51.02	50.48	40.37	64.23	57.36 **

Source: own design based on Eurostat using Prophet model.

Based on the obtained estimates, it is noted that only seven EU member states reach the target for 2025 and only five states reach the one foreseen for the year 2025 (50%). Thus, for the year 2025, we can identify a series of states that register a much higher recycling rate than the European average rate (43.31%), such as Italy, Lithuania, and Spain but also states that are placed far below this average, like Malta, France, and Slovenia.

For the year 2030, the level of the plastic packaging recycling rate of 55% is expected to be reached by Bulgaria, Denmark, Finland, Italy, Latvia, Lithuania, the Netherlands,

Portugal, Slovakia, Spain, and Sweden, at levels that exceed the European average (46.18%). With major potential in reaching this target is Belgium.

With the help of the obtained data, we proceeded to create two dendograms that present clusters of countries having common points of conduct and sharing similar values. Thus, in the no. 1 dendogram (Figure 1), made with the help of the SPSS program [48], we find two important clusters starting from the grouping of countries according to Hofstede's six dimensions and four subclusters in which countries with homogeneous features are gathered. As can be seen, Slovakia does not fit into any cultural typology, being isolated within the dendogram. The six cultural dimensions enunciated by Hofstede are drawn around models of thinking, action, and feeling, and thus he considers that people can be programmed to act based on a cultural model.

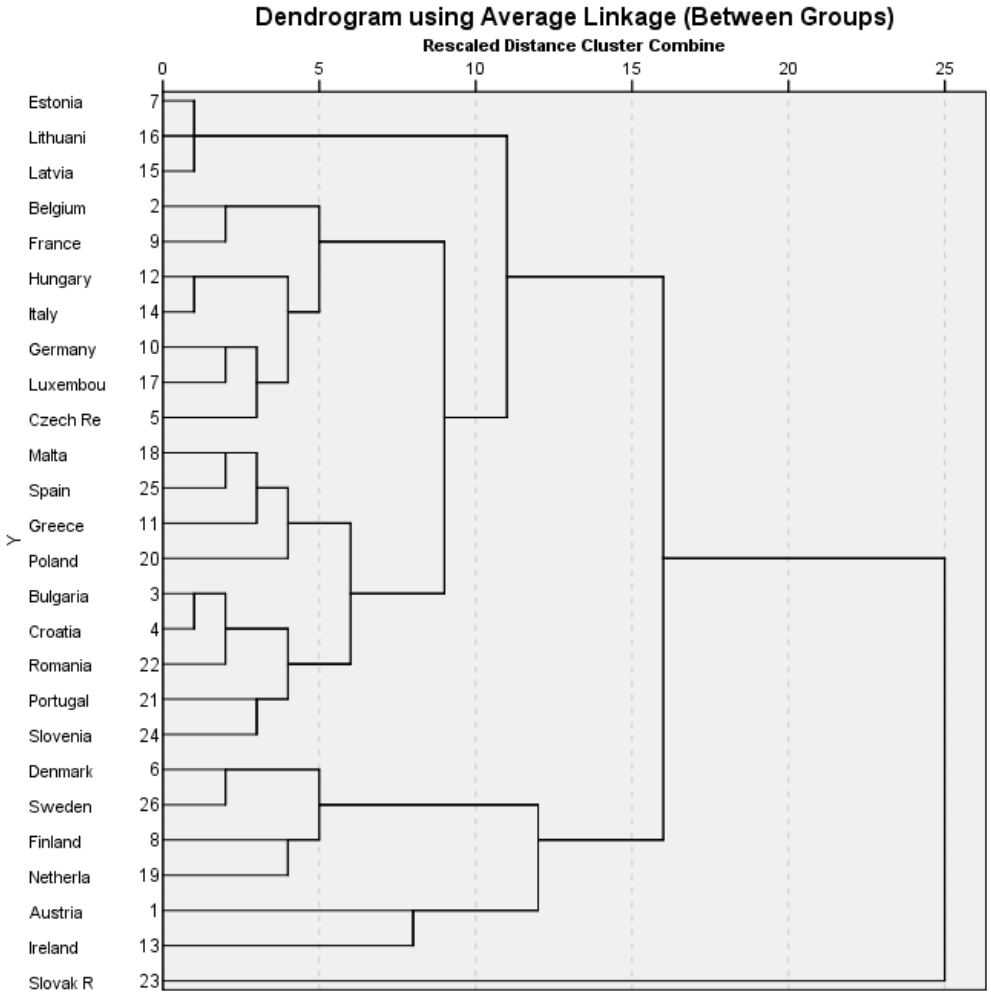

Figure 1. Dendogram including homogeneous clusters of countries at the level of the European Union considering Hofstede's cultural dimensions. Source: own design based on gathered data using SPSS v22.

The second dendogram shows three major clusters formed based on the forecasts of the plastic packaging recycling rate for the period 2022–2030. Within the three clusters, several subclusters are outlined, thus having a mosaic-type layout. This graphic representation offers a clear perspective on the countries that show a similar evolution regarding the indicator of the recycling rate for plastic packaging. Although we can talk about homogeneous clusters at the level of the recycling rate, we notice that they do not overlap with the clusters of countries formed at the level of dendogram number 1. As such,

countries characterized by different cultural dimensions are united by the performance or non-performance achieved in terms of the recycling rate of plastic packaging.

From the cluster analysis carried out with the help of the SPSS program, we observe a mosaic-type arrangement at the level of both clusters. Thus, in the first dendogram (Figure 1), we created clusters and subclusters considering the six cultural dimensions stated by Hofstede: distance from power, individualism, masculinity, uncertainty avoidance, and long-term orientation. In dendogram number two (Figure 2), you can find clusters and subclusters formed by grouping the EU member countries according to the estimates of the recycling rate of plastic packaging related to the interval 2022–2030. Thus, starting from Hofstede's six dimensions, we find two important clusters, within which other subclusters are created considering the similarities from a cultural point of view. Slovakia does not fit into any of the presented clusters, and Cyprus was not integrated in the research considering the lack of information on Hofstede's cultural dimensions. Regarding the dendogram made starting from the recycling rate of plastic packaging, two important clusters and a series of subclusters can be distinguished that highlight the EU member countries grouped from the perspective of efficiency regarding the recycling of plastic packaging.

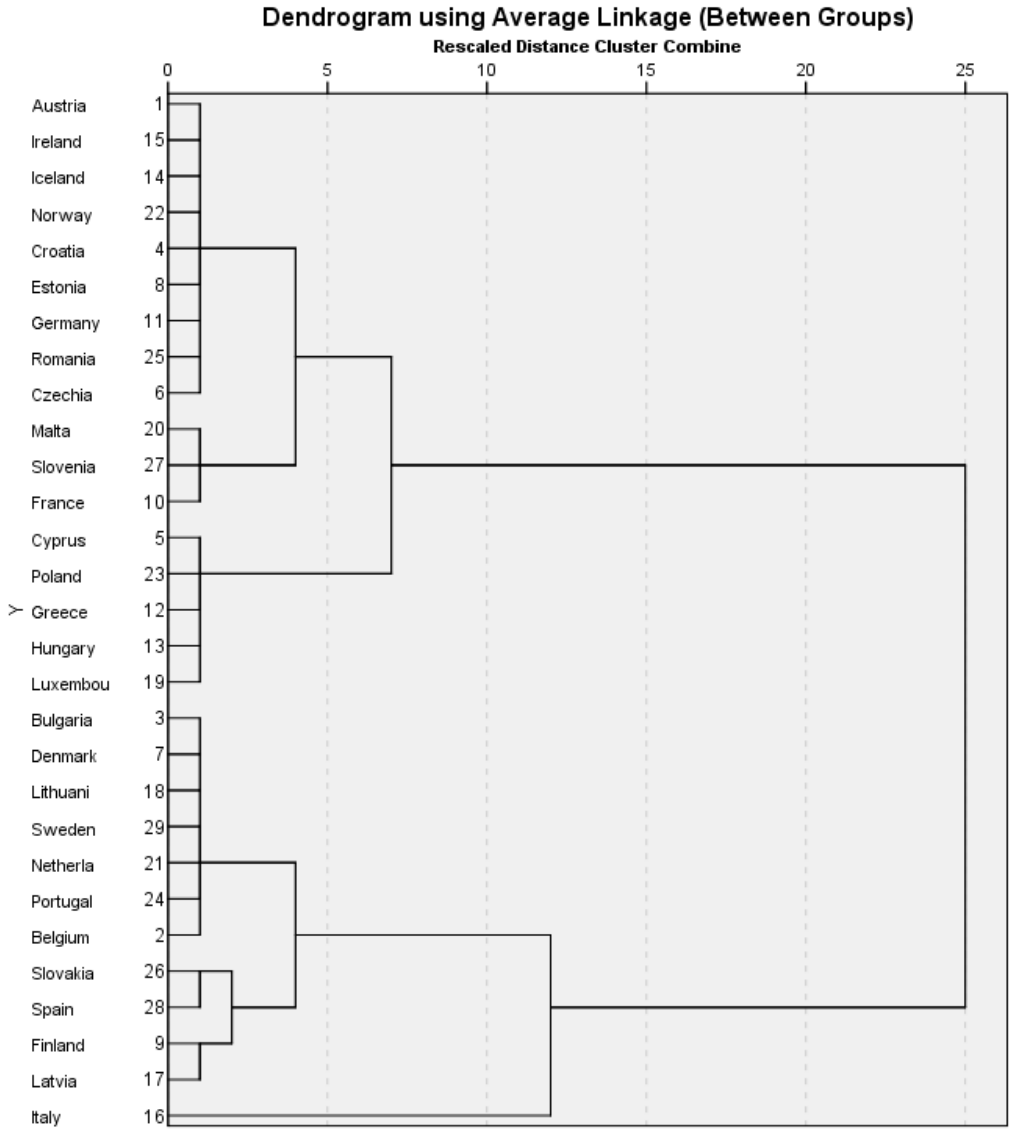

Figure 2. Dendogram including homogeneous clusters of countries at the level of the European Union considering the forecasted recycling rate of plastic packaging. Source: own design based on gathered data using SPSS v22.

The work aims to combine the results obtained at the level of the two clusters and the creation of new groups of countries, within which the countries with a recycling rate of over 50% of the level for 2030 represent the "star" type countries, i.e., countries that succeed in achieving the objectives set by the European Commission and which can communicate their strategy to the countries in the same group but which do not present high-performing recycling rates, thus appealing to the cultural typology in which they fall and which can influence the communication model between countries. Thus, the countries that will manage to reach the objective proposed for the year 2030 (55% recycling rate of plastic packaging) are Bulgaria, Denmark, Finland, Italy, Latvia, Lithuania, the Netherlands, Portugal, Slovakia, Spain, and Sweden. Although, according to the forecast, Belgium does not reach the set objective, it records a plastic packaging recycling rate of over 50% and is assimilated to the "star" countries as a result of the positive evolution.

In the following tables, we will present the countries grouped in subclusters according to the type of predominant culture, the star country/countries in the group, as well as the characterization of the cultural dimensions that govern the group of countries by highlighting their common features.

The first group of countries (Table 3), noted according to the six cultural dimensions, presents a simple, predictable model considering the neighborhood of the analyzed countries, as well as their dimensions. Thus, Estonia, Latvia, and Lithuania, neighboring countries form a homogeneous cluster of countries, at the level of which Latvia and Lithuania are stars, present a favorable forecast regarding the recycling rate of plastic packaging. Estonia, however, presents a negative scenario for the year 2030, recording a recycling rate of 34.37%, falling into the category of totally underperforming countries in this regard. As such, governments and associations will look for a new strategy to implement environmental policies, being able to form alliances with neighboring countries not only from a geographical point of view but also from a cultural point of view.

Table 3. Subcluster A.

Country	PDI	IDV	MAS	UAI	LTOWVS	IVR
Estonia	40	60	30	60	82	16
Latvia **	44	70	9	63	69	13
Lithuania **	42	60	19	65	82	16
Total score	126	190	58	188	233	45
Average	42	63.3	19	62.6	77.6	15

Source: own design based on data from Hofstede's VSM 2013.

Countries with a long-term-oriented culture, such as the countries in this sub-cluster, aim to be open to change and to the future, so cultures with such a vision have a greater ability to embrace change, easily adapting to new programs. Collective thinking aims at long-term advantages, such countries thinking in terms of sustainability. An important role is occupied by the educational component, so the modern education system occupies a significant role in the long-term development process. Countries with a low rate in the masculinity dimension aim for a lower attachment to career, having a tendency towards family and spending free time. A particularly important aspect refers to the image of women in such societies, in which women tend to occupy significant roles in the social hierarchy. Management positions are often occupied by women, thus having a high openness to the portrait of women as leaders. In this context, we consider that the environmental policy can be communicated to the countries in this subcluster by women, speculating on the predisposition of these cultures to value women to the same extent as men.

Regarding the indulgence dimension, we find a very low score at this level, which shows us societies for which social relations are not valued, but rather discipline and morality are valued. At the same time, such cultures do not talk about the importance of free time or freedom of expression. As such, the recycling action will be treated as a moral

obligation towards the environment and not as a pleasant activity, which can be organized in different periods of the year in the form of an action to raise awareness and promote some values.

In the second subcluster, we find seven countries, two of which can be included in the star category, recording outstanding performance in terms of plastic packaging recycling policy. Thus, Belgium and Italy manage to reach the objectives for the year 2030, thus being a model for the five countries in the group that do not register the same performance. It should be noted, once again, that the countries grouped as a result of cultural similarities are also included in the category of neighboring countries. Thus, having as a model the cultural influences that have been transmitted in a certain region, we can hope that such influences will also propagate at the level of environmental strategies.

The countries in subcluster B (Table 4) represent cultures that aim to eliminate risk and establish predictability. At the center of their organization, such cultures have clear, fixed, orderly objections, being cultures skeptical about change. Systems are considered the skeleton of success, with reluctance to change and innovation being the prerogative of this type of culture. Such countries are characterized by a high degree of individualism, with a long-term orientation regarding the policies and strategies implemented, as well as a high degree of masculinity. Thus, a predilection towards the career component is identified, high incomes being an essential element. Managers/leaders are considered the heroes of society, opting for male figures in management positions. As such, the leaders of this group of countries (Belgium and Italy) will impose themselves authoritatively with an aggressive policy that deals with the problem of packaging recycling. The individualism component offers the perspective of establishing individual and not group goals. Thus, those who stand out in the recycling activity can be rewarded without involving the idea of collectivity in achieving the objectives.

Table 4. Subcluster B.

Country	PDI	IDV	MAS	UAI	LTOWVS	IVR
Belgium *	65	75	54	94	82	57
Czech Rep	57	58	57	74	70	29
France	68	71	43	86	63	48
Germany	35	67	66	65	83	40
Hungary	46	80	88	82	58	31
Italy **	50	76	70	75	61	30
Luxembourg	40	60	50	70	64	56
Total score	361	487	428	546	481	291
Average	51.57	69.57	61.14	78	68.71	41.57

Source: own design based on data from Hofstede's VSM 2013.

The third cluster (subcluster C) is also the most complex, as it is represented by nine countries, and there is a slight cultural divide between them. While all nine countries are united by a dominant type of culture, two subcultures still generate a slight fragmentation within the group. The stars of the group are Portugal and Spain, which record recycling rates above the established objective, Spain being significantly different from them. The division already mentioned at the cultural level is also influenced by the fact that the countries in this group are geographically dispersed, so at the cultural level there are other influences that disrupt the homogeneity of the group. At the same time, the differences regarding the sizes of the countries that make up the group are also noticeable, being important oscillations from Spain (<47 million inhabitants) to Malta (<518,000 inhabitants).

The third group of countries (Table 5) is dominated by the UAI dimension, in which all nine included countries register representative scores of over 80 points, the average of

the group being 92.66. Through these data, we can say that all nine countries show a high openness to change, emphasizing innovation.

Table 5. Subcluster C.

Country	PDI	IDV	MAS	UAI	LTOWVS	IVR
Bulgaria	70	30	40	85	69	16
Croatia	73	33	40	80	58	33
Greece	60	35	57	112	45	50
Malta	56	59	47	96	47	66
Poland	68	60	64	93	38	29
Portugal **	63	27	31	104	28	33
Romania	90	30	42	90	52	20
Slovenia	71	27	19	88	49	48
Spain **	57	51	42	86	48	44
Total score	608	352	382	834	434	339
Average	67.5	39.11	42.44	92.66	48.22	37.66

Source: own design based on data from Hofstede's VSM 2013.

Another dimension that governs the analyzed subcluster refers to PDI. Cultures that register a high score on the PDI dimension aim for tolerant behavior regarding social inequalities, accepting the fact that in a society a minority group will hold the power and therefore has the right to a series of benefits in relation to their power. In this context, we consider that the leaders of the group, Portugal and Spain, those who record the best recycling rates for plastic packaging, can establish a package of measures in order to increase the degree of collection and recycling of plastic packaging. Considering the performance obtained, they will be easily tolerated as the states that govern the group, the size of the PDI demonstrating the fact that such cultures consider it normal to distribute power unequally, accepting the differences that may appear at the level of a society. Moreover, all the countries in the group are open to change, accepting new, innovative ideas that can lead to the creation of a modern society. Leadership, as well as its acceptance, is the starting point in consolidating a strategy.

The last analyzed cluster includes six countries, of which four are star countries that manage to reach their goal for 2030 (Denmark, Finland, Sweden, and the Netherlands). Thus, Austria and Ireland are the only countries in the group that do not reach the recycling rates and that are at a considerable distance from the objectives.

In the last analyzed subcluster (Table 6), we note the preponderance of individualism. Considering the geographical position of the countries in the subcluster (slightly isolated), these being positioned in the extreme parts of Europe and not in the center, individualism registers a strong score against collectivism. Thus, countries marked by a strong individualism will value rewards obtained based on merit and not as a group reward. As such, the emphasis will not be placed on group activities, such as the organization of special days for activities carried out in the community, but rather the emphasis will be placed on the creation of clear rules intended to reward the individual for the effort made and not the collective of which the individual is a part.

Moreover, a low rate of recycling is observed at the level of the PDI dimension, which means that such cultures do not tolerate leaders or differences between people in terms of the distribution of power, considering that a strong society will develop on the principle of equality. Thus, the stars of the group will not adopt the attitude of authoritarian leader that is required in the decision-making process in environmental policy, but rather they will be treated as supporting countries which can offer help in establishing a balance at the cluster

level. Thus, we will not find star countries in terms of adopting a coherent environmental policy but rather model countries.

Table 6. Subcluster D.

Country	PDI	IDV	MAS	UAI	LTOWVS	IVR
Austria	11	55	79	70	60	63
Denmark **	18	74	16	23	35	70
Finland **	33	63	26	59	38	57
Ireland	28	70	68	35	24	65
Netherlands **	38	80	14	53	67	68
Sweden **	31	71	5	29	53	78
Total score	159	413	208	269	277	401
Average	26.5	68.83	34.66	44.83	46.16	66.83

Source: own design based on data from Hofstede's VSM 2013.

5. Discussion

This case study, made by combining the forecasts regarding the recycling rate of plastic packaging at the level of the EU member states with information on the type of culture identified by Hofstede at their level, has the role of offering a new perspective on the behavior of the population regarding recycling activity. A series of studies analyzes the behavior of the population in terms of environmental policies and environmental responsibility, but these studies do not offer a complete perspective by explaining social behavior through the prism of culture.

Cardoso [49] talks in his work *E-Waste Management: An Analysis under the Perspective of Conflicts and Shared Responsibility* about the need to educate citizens about environmental activities and increasing consumer awareness, as well as the need to cultivate responsible habits towards environmental policies. Among the measures that are required in the action to increase recycling rates are the organization of educational campaigns, the insertion in primary schools of policies aimed at environmental education, and also the sanctioning of those who do not respect the environmental policies agreed at the national level. In 2008, Heng et al. [50] conducted a study on the factors that influence household members to separate plastic from non-plastic waste. Although all the respondents involved in the study were aware of the need to separate plastic waste, they consider that such an activity can be undertaken effectively if the collection companies are willing to pay even a small amount for the plastic waste selected separately.

Cerqueira-Streit [51] believes that developing countries cannot evolve in the right direction without the institutions involved in sectoral agreements promoting more dialogue in their strategies and also talks about the need to install VDPs (voluntary delivery points), and also about providing support for the cooperatives of collectors of recyclable materials.

Muhammad Waqas et al. [52] conducted a study through which he identified the barriers in the implementation of RL. In this study, it was identified that the barriers aimed at study infrastructure and technology, financial and economic structures, as well as barriers related to knowledge and experience prevail as an impact on the adoption of specific RL policies in front of structures related to laws, regulations, and policies. Thus, a step in the adoption of RL at the organization level consists of addressing the previously stated barriers. The same study draws attention to the fact that barriers related to laws and regulations or barriers related to environmental policies will be dealt with only after solving the problems imposed by the three categories of obstacles. Thus, the managers will deal with the creation of a training system in organizations, and above all, the creation of a common consciousness aimed at issues related to sustainability and durability [53,54].

Of course, all efforts to create a cleaner environment must be measured and quantified so that the applied strategies can be evaluated. Advanced technology represents a valid

way to evaluate the impact of implemented strategies and to impose timely corrections. A series of scientific works show that satellite monitoring is a powerful tool for measuring greenhouse gas emissions and concentrations. Mobile systems [55], CubeSats [56], and other satellites like the TROPOMI in China [57] can be used to make these measurements. Satellite monitoring can provide data on a global scale, which can be used to track changes in greenhouse gas emissions over time and to identify sources of emissions. This information is crucial for crafting effective strategies to combat climate change as it enables researchers to understand emission trends and identify areas requiring targeted solutions. This big-picture view allows scientists to track how greenhouse gas levels fluctuate over vast stretches of time and pinpoint the exact locations where emissions originate.

In conclusion, this case study answers the research questions outlined in the literature review section.

Research question No. 1. Considering the plastic packaging recycling objectives for the year 2030, will there be EU member states able to reach the recycling rate of 55% for the year 2030?

Considering the recycling rates forecast for the year 2030 with the help of the Prophet model, we note that out of the total of 27 EU member states, only 11 of them manage to reach the objective for the year 2030 (55% recycling rate of plastic packaging). The countries that manage to reach this goal are Bulgaria, Denmark, Finland, Italy, Latvia, Lithuania, the Netherlands, Portugal, Slovakia, Sweden, and Spain. At the same time, one more country can also be mentioned, which, although it does not reach the goal foreseen for the year 2030, presents a significant potential so that a slight improvement of the environmental policies can lead to the fulfillment of the goal (Belgium).

Research question No 2. Considering the six cultural dimensions stated by Hofstede, can the EU member states be put together into groups that share common beliefs and values?

Thus, by using the Hierarchical Clusters function from the SPSS program, it can be noted that there are some homogeneous clusters, both at the level of dendogram no. 1, which aims to group countries according to the recycling rate of plastic packaging, and at the level of dendogram no. 2 for the six cultural dimensions stated by Hofstede. Within the clusters, there are both main clusters and subclusters within which groups of countries share similar cultural traits, often acting under the influence of the "country effect".

Research question No 3. In case the member states fail to reach the indicators provided for the year 2030, can we identify an increase in the recycling rate of plastic packaging or a stagnation for the EU member states?

Following the forecast made with the help of the Prophet model, an upward trend can be noted in the recycling rates of plastic packaging; however, some anomalies register at the trend level. For example, countries such as Austria, the Czech Republic, Germany, Malta, Romania, and Slovenia register a downward trend, so, until the year 2030, they move significantly away from the established objective. At the same time, the almost static evolution of countries such as Croatia or France can be noted. At the same time, there are also several countries marked by accelerated growth in the factor of plastic packaging recycling, such as Denmark, Finland, Hungary, Italy, Latvia, Lithuania, the Netherlands, Portugal, Spain, and Sweden. From this mosaic-type distribution of the recycling rate trend, it can be stated that at the EU level, there are policies that work and are applied remarkably, policies that do not work or the way of communicating them is erroneous, and respective policies that do not generate remarkable results but only a series of oscillations at the level of the analyzed period.

Practical implications: This case study offers a new perspective regarding the approach and application of environmental strategies at the level of the EU member states. Thus, a communication corridor was established within the European Union by creating groups of countries similar from the point of view of national culture. As such, the work detaches itself from the rigid, sterile discourses that evoke environmental problems without offering a practical solution by presenting a communication strategy at the level of the EU countries.

The topic addressed presents both a clear forecast of the evolution of plastic packaging recycling rates at the EU level, as well as a method of addressing environmental problems, customized for different countries depending on the different types of culture found at their level.

Political implications: This case study presents a starting point for the governments of EU member countries in that they can seek common solutions depending on the prevailing cultural traits. Thus, alliances can be created between states belonging to a group of countries, appealing to the cultural effect generated by them. Although there are currently a series of rules, regulations, and laws that should favor the increase in the recycling rate at the EU level, by applying the Prophet model, it is noted that only a small part of the EU member countries manage to reach the target imposed by the EU for the year 2030.

Theoretical implications: This paper can be considered a novelty in the field as it presents an atypical association between SDG 17 and national culture. Although apparently these themes do not overlap, being different as a central subject, the type of national culture can positively or negatively influence the behavior of governments or citizens. By creating clusters regarding the predominant culture, we gathered countries that share the same values, customs, or traditions and between which an effective form of communication can be established. At the level of these groups of countries, we have delimited the "star" countries, that is, the countries that can establish the environmental policy applicable at the group level, being countries that, according to the Prophet's forecast, manage to reach the objective for the year 2030. Thus, the communication between these groups of countries will be much easier, having the same communication channel and the same message transmission system. Thus, the chances that the message will be understood, accepted, and implemented at the environmental policy level increase significantly.

Limitations and further research: The current study presents a model of behavior identified at the level of the EU member states, without analyzing the existing environmental policies at the country level in order to adapt them to the requirements imposed by each individual cultural type. As such, the authors propose to develop this work through a careful analysis of the procedures, rules, and laws formulated at the country level and at the cluster level in order to formulate some recommendations regarding their future behavior.

6. Conclusions

The EU prioritizes plastic packaging waste reduction due to its significant pollution impact (61% of all plastic waste). Ambitious recycling targets (55% recycling rate for plastic packaging by 2030) require infrastructure investments, innovation, and incentives for consumers and producers. Innovative business models can minimize waste generation, benefiting the environment, economy, and society. Plastic packaging challenges offer an opportunity for the EU to boost its recycling capacity and industry competitiveness. However, globally, managing plastic waste is complex. As the EU reduces waste exports, it must improve its own recycling infrastructure, especially for lagging member states.

Currently, there are no studies that link the issue of sustainable development to the six cultural dimensions stated by Hofstede. The results obtained at the level of this study can communicate an important message to governments regarding long-term strategies in environmental issues. These strategies, which usually have a formal, rigid, stereotyped character, must be shaped according to the type of culture identified at the state level. The analysis carried out at the level of this study demonstrates significant differences between states in terms of behavior towards environmental policies. These different results are determined by the national collection, recycling and recovery systems, and also by the factors that influence the generation of plastic packaging waste in each member state (population incomes, urbanization dynamics, changing lifestyles and patterns). The EU member countries will continue to develop strategies regarding environmental policies as these issues are more current than ever. Thus, national governments are forced to isolate certain dysfunctional strategies and implement other innovative types. As such, the data provided by the Prophet model highlight the fact that a unitary, common strategy cannot be applied

at the level of all EU member states as they produce different effects for each individual country. This phenomenon can be explained by the cultural differences highlighted in this work and therefore by the grouping of countries into homogeneous groups.

Following the research carried out, we can highlight a series of recommendations regarding the improvement of the recycling rate of plastic packaging starting from the combination of the Prophet forecasting model with Hofstede's cultural model:

- Tailor environmental policies: Consider cultural differences (Hofstede's six dimensions) when developing strategies.
- Analyze national behavior: Understand how existing collection, recycling, and recovery systems influence waste generation.
- Adapt strategies by member state: Address factors like income, urbanization, and lifestyles for impactful solutions.
- Move away from a "one-size-fits-all" strategy: Develop innovative, culturally relevant strategies for each member state.

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