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EVALUATION MODELS FOR THE IMPACT OF PRICING FACTOR ON ENVIRONMENTAL PERFORMANCE IN DIFFERENT COUNTRIES

Abstract

The need to increase the price of non-green, carbon-emitting goods, as well as the application of new environmental taxes and fees to help solving the global climate crisis, has been actively discussed. However, price is not only a strong impetus for market development, but it can also restrain growth. The price level and population purchasing power belong to the key indexes that define the market capacities in different countries. This paper aims to investigate the impact of income inequality, including price levels and purchasing power, on environmental performance in different countries. The research method is based on RapidMiner's machine learning programs, applying three modeling algorithms: correlation, clustering, and decision trees with a static index database of more than 150 countries around the world. The results obtained partially confirm the conclusions made by other researchers studying the Environmental Kuznets concept (EKC) effects. In particular, it was found that an important factor influencing the efficiency of the environment in the country's ecosystem is the level of population's income. The analysis also shows that environmental performance is strongly dependent on domestic price levels. This may support the hypothesis that the cost of green goods reflects a high benchmark for natural resource costs. However, further research is needed, including such directions as sources of financing for the implementation of circular projects, as well as the associated economic and environmental effects.

Keywords environmental performance, purchasing power, circular economy, k-means model, decision tree

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INTRODUCTION

Growing public awareness of the causes and effects of climate change has not resulted in correspondingly high support for specific mitigation or adaptation policies. Thus, more research is needed on the factors influencing civil and corporate support for such climate change policies. Recently, a growing number of international organizations have been pushing in their reports for the necessary increase in carbon pricing, which should spur more significant emissions reduction to help address the global climate crisis (ICAP, 2021), promote emissions trading systems and net zero (World Economic Forum, 2021), and increase climate ambition.

The price can simultaneously be a powerful stimulus for the development of the market, but also a deterrent to its growth. For example, many green products now face the problem of high prices. In particular, a prime example is green hydrogen, which can be used to generate heat and can replace classic fossil fuels (natural gas, LPG, fuel oil, etc.). However, the main reason for holding back the use of hydrogen for

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heating is the low price of thermal energy (EUR/MWh) generated from fossil fuels, particularly natural gas (Jovan & Dolanc, 2020; IEA, 2021). At the same time, the pricing system itself is based on the principles of a resource-intensive economy, when the cost of restoring spent resources is not included in the price of the final product. In this regard, the issue of effective pricing is critical and relevant, which, firstly, would stimulate the development of "green" products and, secondly, would make dirty and environmentally inefficient approaches costly and unprofitable.

One of the key indicators of the markets of different countries is the purchasing power of their population and the price level. Today in different countries, there are different levels of prices for the exact nomenclature of goods. The statistics on the price level coefficient is calculated annually by the World Bank as the ratio of the purchasing power parity (PPP) conversion factor to the exchange rate. It measures differences in price levels between countries by indicating the number of units of a common currency needed to purchase the same amount of the aggregate level in each country. At the level of GDP, they measure differences in general price levels across countries. As can be seen from the World Bank (2020) data, the highest price level is observed in the European countries, including Switzerland (1.21), Iceland (1.07), and Norway (1.06), and the lowest one – in Tajikistan (0.22), Iran (0.17), and Sudan (0.14).

At the same time, it is generally accepted that this difference is due only to a different income level or life of the population. In fact, this means the possibility of arbitrage for international trade. However, the high cost in rich countries may also be due to the high requirements associated with environmental and social responsibility. In addition, green investments and additional tax deductions are widespread in these countries (especially in Europe). For example, in the EU, the final price reaching the consumer on the transport fuel market will consist of three main components: tax-exclusive raw fuel price, environmental tax, and VAT. At the same time, taxes are up to 60% of the final price of fuel, and they are the highest in the case of gasoline and diesel fuel (Jovan & Dolanc, 2020). However, this price is comparable to the price of green hydrogen since environmental taxes will not be applied to it. The lack of environmental taxes is currently the main reason for the competitiveness of green hydrogen in the transport sector.

Thus, on the one hand, the price factor can serve as a barometer for displaying the level of competitive attractiveness for the development of green economy products. On the other hand, it requires additional analysis and explanation of relationships for comparison with the markets of other countries.

1. LITERATURE REVIEW

According to Dasgupta et al. (2021), labor supply and productivity will decrease in the near future due to future climate change in most regions of the world, especially in tropical regions. Some parts of sub-Saharan Africa, South Asia, and Southeast Asia are most at risk under future warming scenarios. Heterogeneous regional response functions suggest that it is necessary to move away from universal response functions to investigate the effect of climate on the labor force. Therefore, negative consequences for the distribution of global income are expected, which will be expressed in increased inequality and poverty. Particularly critical impacts are projected for low-income countries, where the impact of climate change on the workforce will be particularly strong.

1.1. Income inequality and environmental performance

In the context of the objectives of this study, works that explore the relationship between environmental performance and income inequality are of particular interest.

First, it is worth paying attention to the environmental Kuznets curve (EKC) hypothesis, which justifies an inverted U-shaped relationship between various pollutants and per capita income. The concept of EKC originated in the early 1990s with the work of Grossman and Krueger (1991) on the potential impact of NAFTA and the promotion of the concept in the World Bank Development Report 1992 (IBRD, 1992). The point is that environmental pressure increases to a certain level as income rises; thereafter decreases. The EKC shows how the technical measurement of environmental quality changes as the destiny of a country changes. It should be noted that there is a fairly large amount of literature supporting this hypothesis to one degree or another, for example, Cole et al. (1997) and Beckerman (1992). Common to all studies is the statement that environmental quality deteriorates in the early stages of economic development/growth and improves in the later stages.

For example, Hao et al. (2016) argue that the income gap has widened over the past two decades of China's rapid economic growth, and environmental quality has deteriorated. Using the Gini coefficients as a measure of income inequality, they examined the impact of income inequality on China's per capita carbon emissions. Their empirical results showed that per capita carbon emissions increase as the income gap widens across the country and in China's eastern and non-eastern regions. There is a U-shaped relationship between per capita income and per capita carbon emissions among all the factors that can affect per capita carbon emissions. Moreover, an increase in the value added of secondary industry in GDP will significantly increase per capita carbon emissions.

At the same time, many more recent studies have criticized these claims: Dinda (2004), Stern (2004), Blampied (2021), Sun and Wang (2021), and Cole and Lucchesi (2014). Critical remarks can be roughly divided into four main groups.

The first group contained many studies that pointed to the ambiguity of empirical evidence. There is no clear causal relationship between income levels and reduced emissions of pollutants (Onafowora & Owoye, 2014; Aung et al., 2017). For example, the calculated outcomes of Onafowora and Owoye (2014) show that the inverted U-shape EKC hypothesis is valid in Japan and South Korea. In the remaining six countries, the long-run relationship between economic growth and CO2 emissions follows an N-shaped path, and the estimated turning points are much higher than the sample mean. Furthermore, the results show that Granger's energy consumption on average leads to both CO2 emissions and economic growth in all countries.

The second group of critical EKC studies argues that pollution is not simply a function of income but is triggered by many factors (Andreoni & Levinson, 2001). For example, important parameters are the effectiveness of state regulation, economic development, and the level of population.

Almost twenty years ago, Grafton and Knowles (2004) used international data from samples from low-income, middle-income, and high-income countries to present the first empirical test of the relationship between national indicators of social capital, divergence, and potential in terms of various indicators of the country's environmental performance. Overall, the results support the hypothesis that social determinants have a statistically positive effect on national environmental quality but show that higher population density is associated with increased environmental deterioration. Furthermore, the results show that social capital is not always good for the environment. However, higher incomes are not always associated with increased environmental degradation. In conclusion, the logic behind this policy is that improving the country's environmental performance can best be achieved by limiting future growth in population density and reducing emission intensity and costs.

More recently, Cracolici et al. (2010) provided an analytical framework for assessing spatial disparities across countries. It is taken for granted that analyzing a country's performance cannot be limited to economic or social factors alone. The purpose was to combine the relevant economic and "non-economic" (mostly social) aspects of the country's activities into a logical framework. The authors created a structural simultaneous equation model to explore the direction of causality between the economic and non-economic aspects of a country's performance. One of the most interesting findings concerns the inability of most countries to translate the higher educational skills of the population into higher economic performance over time. In addition, their analysis showed that it is highly desirable to draw up an accurate graphic record and formulate appropriate policies aimed at caring for the environment. Surprisingly, only a few countries simultaneously achieved favorable economic and environmental performance.

Morse (2018) also carried out a similar empirical study. Thus, he selected 16 environmental performance indicators for which data were available nationally (180 countries), all of which were components of the Environmental Performance Index (EPI) published in early 2016 and included as dependent variables with income per capita (GDP per capita) and income distribution (Gini coefficient) over almost 20 years as independent variables. The data were analyzed using principal components regression. The results paint a rather complex picture. Some of the EPI component indicators, especially in the Environmental Health category, are related to income and income distribution, while others, especially those focusing on ecosystem health.

The third group includes analysis at the global level and explores the impact of international trade and other factors on the state of the environment. Many developed countries are experiencing a decline in industry and growth in services, but they still import goods from developing countries. In this sense, they export environmental degradation. For example, Rasli et al. (2018) showed that industrial activities significantly increase vehicle emissions and nitrogen monoxide (NOx). In most cases, trade openness, energy demand, and per capita food variability are directly related to air pollutants that degrade the environment.

In this regard, it should be noted that the impact of international trade on the level and distribution of income has been the subject of much attention in the international economy. There have been empirical studies supporting and opposing trade openness. However, in most studies, the authors conclude that the level of income of the population and prices in countries are closely related to the openness of the economy to international trade (Silva & Leichenko, 2004).

Trade has become a means of transporting both clean and dirty (highly polluting) goods, services, and technologies between countries. Although the impact of trade on economic development has been reported in the surviving literature, there are insufficient and conflicting results between pollution-related trade and environmental performance (Alhassan et al., 2020).

At the same time, the question arises regarding the relationship between environmental performance indicators and international trade.

There are a lot of such studies, and they are mainly focused on solving one specific issue. For example, Ali et al. (2021) show that in the long term, environmental innovation, trade, and consumption and income from renewable energy sources are important factors in explaining carbon emissions based on the consumption and emissions of carbon in an area. Therefore, the analysis focused on identifying the role of green innovation, trade, and renewable energy consumption in the relationship between trade and CO2 emissions in the top 10 carbon-emitting countries.

An interesting study was carried out by Alhassan et al. (2020). It examined the role of government good faith in the relationship between trade and the environment in the post-Kyoto era for 79 countries between 2008 and 2018. Empirical results suggest that GDP per capita and government integrity improve environmental performance while trade hinders it. Sustainability analysis using the GMM dynamic panel method shows that the interaction of government honesty with trade yields a positive and significant coefficient. This means that increasing government integrity prevents trade from negatively affecting environmental performance. The study says that outsourcing the rules of operation for trade-oriented multinational companies operating in developing countries with weak institutions to global humanitarian organizations such as the United Nations would be a first step towards reducing trade-related environmental degradation.

Finally, the *fourth group* of critiques of the EKC concept argues that growth always results in more resource use. If the economy continues to expand, inevitably, some resources will continue to be used more. Moreover, there is no guarantee that long-term levels of environmental degradation will continue to decline. For example, Gill et al. (2018) evaluate the relevance of the Environmental Kuznets Curve (EKC) hypothesis to the world's environmental problems. To achieve this goal, various aspects of the EKC have been critically reviewed. The study concludes that the "grow now and cleanly later" EKC growth strategy is too resource-intensive and incurs huge environmental costs that this planet may not be able to absorb in the future. The study's main recommendations are that developing countries should follow a growth path that is different from that of the EKC. A growth path needs to be sustainable and less disruptive. Since energy is the most important determinant of pollution, governments should develop specific renewable energy policies by taxing fossil fuels and subsidizing renewable energy.

1.2. Circular economy: pricing issues

Increasing resource efficiency by slowing, closing, and narrowing material and energy loops is key to climate change mitigation (Gallego-Schmid et al., 2020). Recently, the concept of the development of a circular economy, which is designed to ensure the introduction of a circular production cycle, has been actively discussed in the economic and scientific literature. In particular, recent research has focused on resource reduction solutions that can deliver greenhouse gas savings per functional unit, where material recycling is the most promising alternative. At the same time, it has been pointed out that quantification is vital in all cases, as circular economy solutions do not always automatically lead to emission reductions.

Issues of environmental efficiency are closely related to the concept of sustainable development and circular economy. There is already a large amount of research in this direction. Among the conceptual ones, it is possible to single out Wysokińska (2016), who analyzes the evolution of the new environmental policy of the European Union in the context of efforts made to mitigate the negative effects of climate change. The study describes all activities in the European Union aimed at introducing new EU environmental policy instruments, such as low-carbon technologies, tools that improve the management of limited natural resources, a sustainable transport package, etc. These are intended to lay the foundations for a circular economy, i.e., an economy in which excessive waste is not generated and any waste becomes a resource.

The studies mainly substantiate various aspects of the usefulness of the circular economy as a means of combating the environmental consequences that provoke climate change (Christis et al., 2019; Durán-Romero et al., 2020). For example, Christis et al. (2019) calculated that with circular economy strategies, Brussels could mitigate 25% of CF and 26% of MF, 18% of CF and 26% of MF, as well as 7% of CF and 10% of MF, respectively.

However, some authors insist on the ambiguity of the results and the need for more systematic approaches to the terminology and methods of implementing the principles of the circular to achieve tangible results of efficiency. Thus, Cantzler et al. (2020) note that most studies indicate potential, but implementation remains weak. In particular, they explored additional measures that require, but do not demonstrate, climate change mitigation. They also show that the greatest potential for savings is found in the industry, energy, and transport sectors; average savings in the waste and construction sector; and the smallest increase is expected in agriculture.

Some researchers draw on the need to revalue resources in a circular economy. For example, Di Maio et al. (2017) propose value-based indicators to measure the performance of supply chain members in terms of resource efficiency and circular economy. They advocate measuring both resource efficiency and the circular economy in terms of the market value of 'tight' resources. This value includes elements of scarcity versus competition and taxes representing immediate social and environmental externalities. Using this unit, cyclicality is defined as the percentage of the cost of stressed resources included in a service or product that is returned after the end of their useful life. Resource efficiency is the ratio of the value added of a product to the cost of the strained resources used in a production or process. It is argued that it is the concept of a free market, in which materials, parts, and components are exchanged solely based on their functionality and value, that makes it possible to distinguish the resource efficiency of a process (KPI for industry and management) from the resource efficiency of a product (KPI for consumers and management).

In general, it should be noted that there are relatively few sources devoted to the specifics of pricing in the markets of circular products. Moreover, they often have a fragmentary character. For example, Shen et al. (2019) studied pricing strategies for green and non-green goods. In short, if a green supply chain is truly socially responsible, it must develop a low-compatibility product that can increase its environmental impact. However, this approach does not solve the global problem of mass production of eco-friendly products.

Of interest is the work of Schlosser et al. (2021). At the micro level (firms), they proposed an optimal management model that integrates the recycling rate of a firm that can use both primary and recycled resources in the production process. As shown by their model, which considers the impact of recycling on both the supply and demand side, the positive effect of a firm's use of recycled resources decreases over time but can increase through investment. The focus of their study is to develop more rational methods of sustainable development for firms operating in the circular economy. In doing so, they are studying dynamic pricing and refining investment policies together to determine their optimal synergy over time. However, as noted above, this paper is more focused on practical application at the micro level and does not set tasks related to the analysis of global factors influencing the cost of resources.

Therefore, after summarizing the literary sources, the following conclusions can be drawn. First, there are two main development scenarios for countries regarding environmental performance:

1) in accordance with the environmental Kuznets curve (EKC), by increasing incomes with the hope that in the future, they will lead to qualitative changes in the environment;

2) an alternative scenario, which provides for the immediate introduction of the principles of decoupling and a circular economy, focused on the simultaneous growth of incomes and the quality of the environment.

Obviously, the second scenario is more promising, but the question arises of how to achieve it.

Second, the circular economy provides for an increase in the efficiency of resource use by slowing down, closing, and narrowing the material and energy loops. Many researchers talk about the specifics of the price factor for the market for circular and environmentally friendly products. However, the analysis showed that the existing studies are still fragmentary.

Consequently, despite many studies in the field of environmental efficiency, the circular economy, and various macroeconomic and social parameters, many questions still remain open, which led to the goal of this study.

Therefore, this paper aims to explore all aspects of the impact of price levels and purchasing power on environmental performance in different countries based on the RapidMiner's machine learning program.

2. METHODS

To analyze the factors affecting the environmental efficiency index, including the price level and purchasing power in the country, it is proposed to use the particular assessing model (Figure 1).

The first stage of index selection involves the choice of indicators: responsible for comparing prices, population incomes and international trade across countries. In addition, the Environmental Performance Index (EPI) has been chosen as an indicator of a country's environmental performance.

In this context, the proposed ultimate goal is to test the following hypothesis: in most cases, the market provided an incorrect principle of pricing for goods, which led to a distortion of the cost of their production due to ignoring the costs associated with the need to restore the natural conditions of the Earth.

For instance, the traditional price function is determined by the balance of supply and demand. At the same time, the offer price depends on the cost of production of goods, margins and the level of taxes.

$$P_t = C_t + M_t + T_t, \qquad (1)$$

where P_t – traditional (classic) pricing of goods; M_t – seller's (manufacturer's) profit margin; T_t – taxes.

In practice, however, to maintain a balance in nature, it is imperative to include in the price the cost

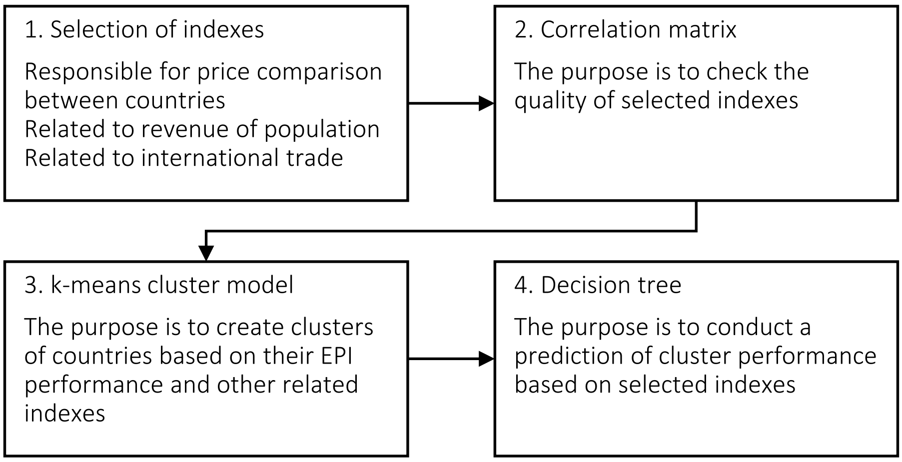

Figure 1. Model for assessing the impact of price levels and purchasing power on environmental performance in different countries

Source: Developed by the authors.

of restoring natural resources used to produce goods. Thus, the pricing formula should look like this:

$$P_F = P_t + C_R, \tag{2}$$

where P_F – full (real) price, taking into account the restoration of spent resources; C_R – the cost of restoring spent resources in the future; P_t – traditional (classic) price of goods.

In this regard, if each commodity is to be revalued and reflect the real value of the principles of the global economy, it should be completely revised.

At the same time, some countries have begun to actively stimulate the development of so-called circular production, which involves significant investment in the development of new technologies designed to increase the usefulness and value of the resources needed for production. The governments of these countries are actively stimulating the development of these areas, including through regulatory methods. Accordingly, prices in such countries for products differ significantly since these are mainly developed countries.

Thus, it seems appropriate to compare the price level in different countries and the key factors that can significantly affect these prices – income level, taxes, economic openness, etc.

Analysis of the data used to determine EPI 2018 revealed 24 individual environmental indicators used in the calculations, grouped into a hierarchy of ten categories:

1) air quality;
2) water and sanitation;
3) heavy metals;
4) biodiversity and habitat;
5) forests;
6) fisheries;
7) climate and energy;
8) air pollution;
9) water resources;
10) agriculture.

These categories are further combined into two that form the target policy – environmental protection and ecosystem health – and, finally, a standard indicator. To provide meaningful comparisons, the paper scores each of the 24 metrics on a standard scale, with 0 being the worst performance and 100 being the best. The remoteness of a country from achieving international sustainable development goals determines its location on such a scale. The numbers are then multiplied by the weights and summed up for the final EPI calculation.

In *the second stage* of the Correlation matrix, the quality of the links between the selected indicators is examined.

In *the third stage*, it is necessary to build a model for clustering countries according to the EPI index. It is proposed to use the k-means cluster model as such a model. According to the data of the RapidMiner application, it is the k-means model that the application should be used to solve problems with database segmentation into clusters.

The fourth stage includes a direct forecast of the environmental performance cluster of a country based on a comparison of its price and purchasing power parameters. For this, the best option is the decision tree model (MOD by RapidMiner).

Due to the universality of the methodological apparatus, the decision tree has industry applications both in different areas of economic science (which is reflected, for example, in the works, and in other areas of activity, in particular, in information systems and the management of technical systems (Patel & Prajapati, 2018). Furthermore, the ability to include both qualitative and quantitative information in the decision tree allows for analyzing the frequencies of phenomena, events, and objects (including the compatibility of frequencies of different combinations of events).

Thus, the combined application of the decision tree method and associative analysis makes it possible to reduce the amount of calculations by combining them, increase the visibility and interconnectedness of the results of the analysis of particular problems, and thereby increase business efficiency by increasing the validity and efficiency of management decisions (Chandrasekar et al., 2017).

3. RESULTS

At the initial stage, static data are collected, including indexes on environmental performance, price level ratio of PPP conversion factor (GDP) to market exchange rate, merchandise trade (% of GDP), exports and imports of goods and services (% of GDP), GDP per capita (current USD) and GDP growth (annual %) to calculate the model (Table 1).

3.1. Correlation matrix

Further, a correlation analysis was carried out between the collected statistical data (Table 2), which showed a strong relationship between the environmental efficiency index (EPI) with price level ratio of PPP conversion factor (GDP) to the market exchange rate (0.70), and GDP per capita (0.81).

3.2. Application of k-means model for cluster creation

It is clear that achievements in environmental efficiency vary from country to country. On the other hand, in order to generalize the results and highlight patterns, it is necessary to divide countries into clusters. Therefore, the next step involved country subgrouping, for which the RapidMiner software package was used, namely the k-means clustering model. It was revealed that the environmental efficiency index has a high correlation coefficient with the parameter responsible for the price level in the country (price level ratio of PPP conversion factor (GDP) to market exchange rate). These indicators were taken to build the clustering model k- means. As a result of the calculations, three clusters of countries were obtained (Figure 2).

The model also allowed to obtain boundary values for grouping countries by the EPI parameter and Price level ratio of PPP conversion factor (GDP) to the market exchange rate. The results are presented in Table A1, where the countries are divided into clusters by applying the above methodological approach to the environmental indicators analysis.

Table 1. Key indicators

Source: Developed by the authors.

Index	Type	Source
Price level ratio of PPP conversion factor (GDP) to market exchange rate	Attribute X(1)	Merchandise imports (% of GDP) – 2020. World Bank Data.
Exports of goods and services (% of GDP)	Attribute X(2)	New businesses registered (number) 2018.
Imports of goods and services (% of GDP)	Attribute X(3)	Foreign direct investment, net (BoP, current USD) 2018.
GDP per capita (current USD)	Attribute X(4)	GDP per capita (current USD) – 2020. World Bank Data.
GDP growth (annual %)	Attribute X(5)	GDP growth (annual %) – 2020. World Bank Data.
Merchandise trade (% of GDP)	Attribute X(6)	Merchandise trade (% of GDP) – 2020. World Bank Data.
GDP (current USD)	Attribute X(7)	GDP (current USD) – 2020. World Bank Data.
EPI, 2020	Class label (Y)	2020 Environmental Performance Index.

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Table 2. Correlation matrix

Source: Developed by the authors using RapidMiner engine.

Index	Price level ratio of PPP conversion factor (GDP) to market exchange rate	Exports of goods and services (% of GDP)	Imports of goods and services (% of GDP)	GDP per capita (current USD)	GDP growth (annual %)	Merchandise trade (% of GDP)	GDP (current USD)	EPI, 2020
Price level ratio of PPP conversion factor (GDP) to market exchange rate	1.00	0.33	0.22	0.82	–0.13	0.06	0.18	0.70
Exports of goods and services (% of GDP)	0.33	1.00	0.90	0.55	0.00	0.68	–0.08	0.41
Imports of goods and services (% of GDP)	0.22	0.90	1.00	0.39	–0.11	0.66	–0.17	0.26
GDP per capita (current USD)	0.82	0.55	0.39	1.00	0.03	0.18	0.14	0.81
GDP growth (annual %)	–0.13	0.00	–0.11	0.03	1.00	–0.04	0.09	–0.14
Merchandise trade (% of GDP)	0.06	0.68	0.66	0.18	–0.04	1.00	–0.11	0.27
GDP (current USD)	0.18	–0.08	–0.17	0.14	0.09	–0.11	1.00	0.13
EPI, 2020	0.70	0.41	0.26	0.81	–0.14	0.27	0.13	1.00

3.3. Building a decision tree model

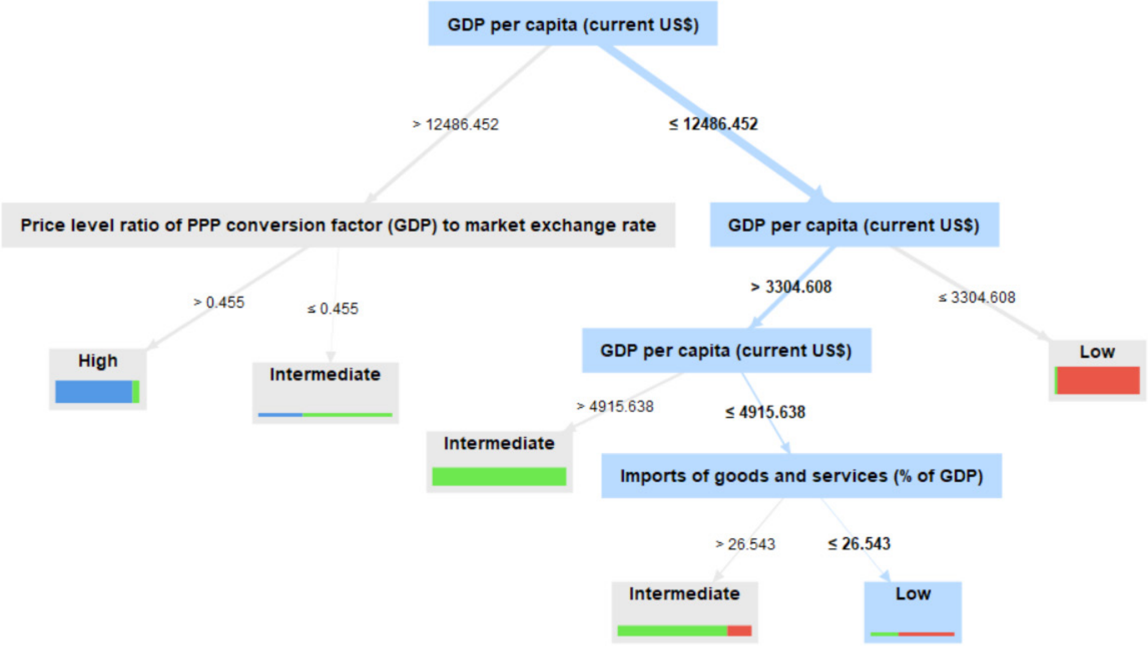
The third stage includes applying the RapidMiner software package for building a decision tree to predict which cluster of environmental performance the country will belong to, depending on its indicators of price level, purchasing power, international trade openness, etc. (the database is presented in Appendix A). Figure 3 shows the plotting results.

Based on the analysis, it is possible to conclude that the key factor influencing the efficiency of the environment in the national ecosystem is the level of income of the population. In countries where this indicator is higher than USD 12,486/year, it is either high or the average level of EPI. Furthermore, a significant influence of the price level in the country on the ecological compatibility of the ecosystem has been revealed. Thus, countries with high average prices (more than 0.455) have high environmental efficien-

Source: Developed by the authors using RapidMiner engine.

Note: Cluster Model: Cluster 0: 48 items; Cluster 1: 50 items; Cluster 2: 34 items; Total number of items: 132.

Figure 2. K-means model of clusterization of countries by EPI



Source: Developed by the authors using RapidMiner engine.

Figure 3. Decision tree for classification of environmental performance cluster

cy. When this indicator is below 0.455, the countries are mainly in the medium-efficiency cluster. With GDP per capita in a country below USD 3,304/year, countries are in the low environmental efficiency cluster. Countries with a per capita GDP greater than USD 4,916/year but less than USD 12,486/year would be in the middle-efficiency cluster. Finally, those whose GDP indicator is in a narrow range from 3305 to 4916 USD/year belong to the middle cluster (in 77% of cases) or low (23%).

A low level of correlation was also revealed between the EPI indicator and the openness of the country's economy, particularly the turnover of export-import operations concerning GDP.

4. DISCUSSION

On the one hand, the results obtained confirm the conclusions made by other researchers. In particular, a direct relationship exists between the income level of the population and environmental efficiency indicators. However, on the other hand, high dependence on the level of prices in the country was revealed, which confirms the hypothesis that the cost of goods in green regions reflects higher standards regarding the cost of natural resources.

First, there must be a global audit of existing resources, both renewable and non-renewable. The cost of non-renewable sources should be reviewed. Moreover, recycling programs are needed that could drastically reduce their consumption, as well as programs for the development of substitutes (for example, green energy instead of gas, hydrogen economy, and so on). As for renewable sources, one of the critical parameters should be the renewal period – the longer, the more expensive.

Second, it will lead to higher prices and "unavailability of many benefits" for the masses. On the other hand, ownership can be swapped for rent in many industries, ranging from cars and homes to sports equipment. In this regard, it is important to change the consciousness – to rent "good," as it means less and more efficient consumption.

The question is how to recover the resources spent. The first option is when the government collects the payment as a tax, part of which can be seen in tax increases in the EU. The second option is when the producers themselves are placed in conditions of physical resource constraints and are forced to implement a recovery/recycling system. The implementation of such transformations should combine these two approaches.

Future promising lines of research should include the following points. First, the sources of financing for the implementation of circular projects must be investigated. On the one hand, a higher selling price of green goods should provide a faster payback; however, the risks here are also much higher (especially the risk of substitutes and technological risks), and it is often difficult for traditional sources of financing to assess them. Therefore, special mechanisms are needed, including tax incentives, grants, special programs, green bonds, etc.

Second, further research related to the use of digital technologies to manage circular business models and predict the optimal price and the associated economic and environmental effects could be very relevant.

Finally, it is essential to understand the clear mechanisms of the positive impact of international trade on the pricing of green goods since this study has not revealed a positive correlation here. Therefore, more in-depth research is needed.

CONCLUSION

The aim of this paper was to study all aspects of the influence of the pricing and the openness of the economy on environmental efficiency. Application of the RapidMiner software package allowed building a decision tree for predicting the state of the environment under various combinations of factors affecting the development of the ecosystem. Based on the analysis, it can be concluded that the critical factor affecting the efficiency of the environment in the national ecosystem is the population's income level. In countries where this indicator is higher than USD 12,486/year, it is either high or the average level of EPI. A significant influence of the price level in the country on the ecological compatibility of the ecosystem has been revealed. Thus, countries with high average prices (more than 0.455) have high environmental efficiency. If this indicator is below 0.455, the countries are mainly in the medium-efficiency cluster. With GDP per capita in a country below USD 3,304/year, countries are in the low environmental efficiency cluster. Countries with a per capita GDP greater than USD 4,916/year but less than USD 12,486/year would be in the middle-efficiency cluster. Finally, those whose GDP indicator is in a narrow range from 3305 to 4916 USD/year belong to the middle cluster (in 77% of cases) or low (23%).

The strong relationship between the Environmental Condition Index (EPI) and national price levels (0.73) suggests that resource-pricing principles need to be revised, especially in countries with a third cluster (low).

A low level of correlation was also revealed between the EPI indicator and the openness of the country's economy, in particular, the turnover of export-import operations concerning GDP. Moreover, this situation is also typical for the EU countries, where there are additional environmental taxes on many groups of goods. This may support previous conclusions that the relationship between environmental efficiency and export-import operations is skewed because there is a decline in industry and growth in the service sector in any developed country. However, they still import goods from developing countries. Thus, they export environmental degradation. Therefore, it would be more appropriate to apply a methodology that takes into account the import-export of the carbon footprint.

On the one hand, the results obtained partly confirm the conclusions made by other researchers (critics of EKC theory). In particular, there is a direct relationship between the population's income level and indicators of environmental efficiency. On the other hand, a high dependence on the level of prices in a country and its environmental indexes was revealed, which can confirm the hypothesis that the price of green goods reflects higher standards regarding the cost of natural resources. This means that potentially environmentally friendly goods, in the case of cost optimization, will have a higher margin and, ultimately, investment attractiveness.

AUTHOR CONTRIBUTIONS

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APPENDIX A

Table A1. Clusters of countries by EPI index

Source: Developed by the authors using RapidMiner engine.

Cluster EPI Performance	Low	Intermediate	High
Cluster	Cluster 0	Cluster 1	Cluster 2
Price level ratio of PPP conversion factor (GDP) to market exchange rate (average)	0.397062	0.42226	0.775483
EPI, 2020 (average)	32.00208	48.02	71.82353
Countries	Kyrgyz Republic, Iraq, Bhutan, Nicaragua, Sri Lanka, Philippines, Burkina Faso, Malawi, Tajikistan, Equatorial Guinea, Honduras, Indonesia, Kiribati, Sao Tome and Principe, China, Qatar, Zimbabwe, Central African Republic, Congo, Dem. Rep., Guyana, Maldives, Uganda, Timor-Leste, Lao PDR, Sudan, Kenya, Zambia, Ethiopia, Fiji, Mozambique, Rwanda, Eswatini, Cameroon, Cambodia, Vietnam, Pakistan, Cabo Verde, Nepal, Papua New Guinea, Mongolia, Comoros, Guatemala, Tanzania, Nigeria, Congo, Rep., Niger, Senegal, Benin, Angola, Togo, Mali, Guinea-Bissau, Bangladesh, Vanuatu, Djibouti, Lesotho, Gambia, Mauritania, Ghana, India, Burundi, Haiti, Solomon Islands, Chad, Madagascar, Guinea, Cote d'Ivoire, Sierra Leone, Afghanistan, Myanmar, Liberia	Seychelles, Singapore, Bulgaria, North Macedonia, Chile, Serbia, Brunei Darussalam, Jordan, Belarus, Colombia, Mexico, Costa Rica, Armenia, Argentina, Brazil, Ecuador, Russian Federation, Ukraine, Uruguay, Albania, Antigua and Barbuda, St. Vincent and the Grenadines, Jamaica, Iran, Malaysia, Trinidad and Tobago, Panama, Tunisia, Azerbaijan, Paraguay, Dominican Republic, Montenegro, Gabon, Barbados, Bosnia and Herzegovina, Lebanon, Thailand, Suriname, Mauritius, Algeria, Kazakhstan, Dominica, Moldova, Bolivia, Uzbekistan, Peru, Saudi Arabia, Bahamas, Egypt, Grenada, St. Lucia, El Salvador, South Africa, Turkey, Morocco, Belize, Georgia, Botswana, Namibia	Denmark, Luxembourg, Switzerland, United Kingdom, France, Austria, Finland, Sweden, Norway, Germany, Netherlands, Australia, Spain, Belgium, Ireland, Iceland, Slovenia, New Zealand, Canada, Czech Republic, Italy, Malta, United States, Greece, Slovak Republic, Portugal, Korea, Rep., Israel, Estonia, Cyprus, Romania, Hungary, Croatia, Lithuania, Latvia, Poland