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FINANCIAL AND NON-FINANCIAL ASPECTS OF ENVIRONMENTAL POLICY OF THE EUROPEAN UNION COUNTRIES USING THE CLUSTER ANALYSIS METHOD

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Purpose: The aim of the article was to create homogeneous groups of European Union countries with similar characteristics of applied environmental policy - fiscal and non-fiscal
Design/methodology/approach: In order to group countries according to their environmental policy, the author selected variables based on Eurostat data and then applied the Ward method, which is one of the cluster analysis methods.
Findings: The method divided the EU countries into six clusters. The degree of homogeneity of the resulting country groups is still under discussion.
Research limitations/implications: The results of the F-test for variance show that it was not possible to achieve complete homogeneity of the groups created. In practice, it is very difficult to meet this criterion for all variables, and in turn, the separation of a larger number of country groups would be contrary to the assumptions of the cluster analysis method. The selection of a set of diagnostic variables, which is always a subjective choice, also remains a contentious issue.
Originality/value: The countries of the European Union have been divided into groups according to their environmental policy based on the proposed criteria.
Keywords: environmental policy, cluster analysis, Ward's method**.**
Category of the paper: Research paper, Literature review.

1. Introduction

The European Community is facing complex environmental problems. These range from climate change and biodiversity loss to resource depletion and environmental pollution. To solve these problems, European environmental policy has as its basis the principles of precaution, prevention, removal of pollution at the source, and the "polluter pays" principle. In 2019. Commission launched the European Green Deal and put environmental issues at the forefront of its policy (Kurrer, Petit, 2024).

Each of the 27 European Union countries also has its own policies (fiscal and non-fiscal) in the area of environmental protection. This is primarily due to the specific characteristics of the economies of these countries, the natural resources and protected areas they possess, the degree of energy transition to date, but most importantly, to their wealth and current financial capabilities. It seems particularly interesting to find Member states, which have similar approaches to the measures they apply, so that it will be possible to see if they have any common features and create their classification.

One of the statistical methods to implement this type of classification is cluster analysis. The concept of cluster analysis actually includes several different systematization algorithms. The general problem for researchers in many disciplines is to divide data into logical structures or grouping of data (Statsoft, 2024). In other words, cluster analysis is a tool for exploratory data analysis, the goal of which is to arrange objects into groups in such a way that the degree of association of objects with objects belonging to the same group is as high as possible, and with objects from other groups as low as possible (Gatnar, Walesiak, 2004).

The main purpose of this paper is to group European Union countries by the characteristics of their environmental policies.

The first part of the article will present the current areas of research that researchers are dealing with in the context of environmental policy. In the next part, the author will characterize the research material, and then make a grouping of the European Union countries due to the environmental policy pursued by the public authority using the Ward method (which is one of the methods of cluster analysis).

The study was based on an analysis of the literature on the subject and Eurostat data from 2018-2021.The selection of just such a period was due to the availability and completeness of data for all European Union member states.

2. Environmental policy – a review of the literature

The environmental policies of state governments are attracting considerable interest among the public as well as among environmental organizations, understandably and largely due to rapid climate change. In recent years, there has also been growing interest in the subject among scientists. For the purpose of this paper, the latest research related to environmental policy was reviewed, in order to identify current trends and research directions in this area.

Prominent among the 2018-2023 global studies is the interest of researchers in: the im-pact of environmental policies applied by national governments on reducing greenhouse gas emissions, the impact of environmental policy variability on business investment, the impact of environmental policies on renewable energy sources, the use of cluster analysis to analyze greenhouse gas emissions-see Table 1.

Table 1.
Research in the area of environmental policy - foreign authors

Authors	Year	Research topics	Applications
Yongbum Kwon, Hyeji Lee, Heekwan Lee	2018	Using cluster analysis to analyze greenhouse gas emissions in Asian countries.	A division of Asian countries into 6 groups with different characteristics was made. Emission areas requiring urgent corrective action were identified.
S. Almeida Neves, A. Cardoso Marques, M. Patrício	2020	Determinants of CO_2 emissions in European Union countries: do environmental regulations reduce pollution?	Environmental regulation is effective in reducing CO_2 emissions in the long term. The study was based on data from 17 EU countries.
Y. Wolde-Rufael, E. Mulat-Weldemeskel	2021	Do environmental taxes and restrictive environmental policies reduce CO_2 emissions in developing economies?	There is an inverse relationship between the multiplicity of CO_2 emissions and the stringency of environmental policy.
Dan Zhang, Mingbo Zheng, Gen-Fu Feng, Chun-Ping Chang	2022	Does environmental policy bring green innovation to renewable energy?	Restrictive environmental policies increase renewable energy production. Studies also show that strict environmental policies bring "green innovation".
C. Albulescu, M. Boatca-Barabas, A. Diaconescu	2022	Asymmetric impact of environmental policy stringency on CO_2 emissions in OECD countries.	Pursuing strict environmental policies is more effective in countries with lower greenhouse gas emissions.
Yingde Hu, Wensong Bai, Muhammad Farrukh, Chun Kwong Koo	2023	How does environmental policy uncertainty affect green business investment?	The study found that environmental policy uncertainty can significantly inhibit companies' green investments.

Source: own elaboration based on: (Kwon, Lee, 2018; Almeida Neves, Cardoso Marques Patricio, 2020; Wolde-Rufael, Mulat-Weldemeskel, 2021; Zhang, Zhang, Feng,Chang, 2022; Albulescu, Boatca-Barabas, Diaconescu, 2022; Hu, Bai, Farrukh, Koo, 2023).

Among Polish scientists, there is also interest in environmental policy issues - these are mainly: studies on environmental taxes, surveys of opinions regarding Poland's climate policy, a study of the importance of environmental policy in the context of ecological innovation, and analysis of national and international environmental legislation- see Table 2.

Table 2.
Research in the area of environmental policy - Polish authors

Authors	Year	Research topics	Applications
A. Baran	2024	Environmental governance in the European Union – an overview of environmental policy actions	The article reviews the most important environmental management activities in the European Union by reviewing European policies, programs and regulatory frameworks, and identifies issues of concern in this area.
M. Paradowska, J. Platje, A. Suchecka	2023	Polish climate policy in the opinion of young Poles – pilot survey	The results showed respondents' awareness and relatively high interest in the risks of climate change, but lacked in-depth knowledge of climate change, climate policy and its socioeconomic implications. The advancement and effectiveness of climate policy in Poland was also rated rather negatively.

Cont. table 2.

J. Godawska	2024	Impact of environmental taxes on NO_x and SO_x emissions	The results show that revenues from environmental taxes have a negative and statistically significant, but rather symbolic, effect on SO_x emissions, while these revenues have no effect on NO_x emissions.
J. Godawska	2024	Does environmental policy matter for eco-innovation? Evidence from EU countries	The higher rigor of technological support and market instruments has a positive impact on patents related in EU countries.
R. Marushkin, J. Bednarek	2024	Climate protection in European Union law and in Polish law	The article discusses the provisions on climate protection contained in acts of European Union law and in Polish law.
K. Tomaszewski	2024	Global Climate Policy and Religion – the Case of Pope Francis	The fusion of political and religious activities contributes to the promotion of environmental and climate goals and the growth of public awareness
W. Szymański, J. Węgrzyn	2024	Fiscal efficiency of the green transformation of the tax system on selected examples of European Union Member States	The authors indicate that the most appropriate group of taxes that can be an effective instrument to support the green transformation policy are indirect taxes.

Source: own elaboration based on: (Baran, 2024; Paradowska, Platje, Suchecka, 2023; Godawska, 2024a, 2024b; Bednarek, Maruszkin, 2024; Tomaszewski, 2024; Szymański, Węgrzyn, 2024).

3. Characteristics of the research material

The initial dataset for the analysis of spatial variation in environmental policies pursued by European Union countries in 2018-2021 included all values of environmental and environmental policy indicators for the 27 European Union countries available in the Eurostat database.

Due to the large number of variables, substantive verification was carried out. Variables were divided into those that show the specific actions of governments (financial and non-financial) in the area of environmental policy and those that are the result of such actions - the selection was made from among the variables that define the actions of public authorities - examples of variables that were analyzed in the selection process are presented in Table 3.

Table 3.
Environmental policy actions and their effects - analysis of sample variables

Variable	Variable that determines the actions of the public authority in the area of environmental policy	Variable determining the effects of environmental policy	Comments
Net per capita greenhouse gas emissions (financial)		X	The volume of greenhouse gas emissions from the so-called "Kyoto basket" is the result of the environmental policy adopted

Cont. table 3.

Average air temperature (non-financial)		X	Climate change is the result of environmental measures taken
Share of protected areas in the country's area (non-financial)	X		The creation of legally protected areas is part of the environmental policy of the state and the EU and can contribute to more effective environmental protection in the future and to counteract environmental degradation
Average electricity price per kWh (financial)	X		The price of energy for households is an element of regulation at the national and European level, which can influence the decisions of consumers energy in the context of choosing more ecological (usually cheaper) energy source.
The amount spent from the national budget to contribute to the international commitment of $100 billion a year to finance activities related to combat climate change under the United Nations Framework Convention on Climate Change per capita (financial)	X		The contributions are part of the governments' global environmental policies showing commitment to the process.
Share of revenue from environmental taxes as a percentage of GDP (financial)	X		The environmental tax policy adopted is part of a "penalty and incentive system and incentives," which is designed to change the behavior of taxpayers.

Source: own elaboration based on: Eurostat (2024).

Environmental policies pursued by individual EU countries were characterized by the following variables after substantive analysis:

X_1 - Average price of electricity in euros per kWh, including taxes and fees in effect in the first six months of the year for medium-sized households (annual consumption of 2500 to 5000 kWh) in 2018-2021 - financial type variable.

X_2 - Share of environmental tax revenues[1] in GDP - average value in 2018-2021 - financial type variable.

X_3 - State budget expenditures on environmental protection as % of these expenditures in total state budget expenditures - financial type variable.

X_4 - Nationally designated protected areas and Natura 2000 sites, as a percentage of protected areas in the national area - average value for years 2018-2021 - non-financial variable.

[1] Environmental taxes are in this case: energy taxes, taxes on means of transportation, taxes on emissions/owned resources.

X_5 - The total amount disbursed from the annual state budget for the international commitment of $100 billion per year to finance climate change measures under the United Nations Framework Convention on Climate Change per capita in 2018-2021 - a financial type variable.

X_6 - Employment in the environmental goods and services sector, as a percentage of the employed in the sector relative to the country's active workforce - average value for 2018-2021 - non-financial variable.

The possible reduction of variables in the first phase was based on an analysis of their variability, and in the next phase the basis for the selection of diagnostic features was a matrix of correlation coefficients.

Table 4.
Coefficients of variation of diagnostic characteristics

Diagnostic features	Volatility factor
X_1	29,40%
X_2	27,50%
X_3	38,87%
X_4	38,42%
X_5	146,49%
X_6	47,60%

Source: own elaboration.

In the first phase of reducing the set of diagnostic characteristics, the task was to eliminate quasi-constant variables. In the adopted set of variables, the average value of the coefficient of variation was 54.71%. Thus, the value of this coefficient exceeded the critical value of 10% for all selected 6 diagnostic features - see Table 4.

The further part of the selection procedure was aimed at eliminating variables yielding similar information and was carried out using the parametric method. The critical value of the correlation coefficient was taken as 0.7. The parametric method used allowed to select the final list of representatives on the basis of the matrix of modules (absolute values) of correlation coefficients - see Table 5.

Table 5.
Matrix of moduli of correlation coefficients between diagnostic features

Variable	X_1	X_2	X_3	X_4	X_5	X_6
X_1	**1**	0,22628	0,23055	0,215854	0,507522	0,027404
X_2	0,22628	**1**	0,159891	0,114942	0,306229	0,128501
X_3	0,233055	0,159891	**1**	0,236163	0,13058	0,289398
X_4	0,215854	0,114942	0,236163	**1**	0,076955	0,155462
X_5	0,507522	0,30623	0,136058	0,076955	**1**	0,313278
X_6	0,027404	0,1285	0,289398	0,155462	0,313278	**1**

Source: own elaboration.

In the analysis of financial and non-financial aspects of environmental policy of community governments, the final group of diagnostic characteristics includes a total of the following six variables: X_1, X_2, X_3, X_4, X_5, X_6. These were used to determine the number and composition of the segments of countries with similar environmental policies in 2018-2021.

4. Grouping EU countries according to their environmental policy using the Ward method

Based on the research carried out so far, the particular usefulness of the Ward method of one of the many possible methods of cluster analysis is confirmed, which is included in the group of hierarchical methods. Clustering by Ward's method consists in combining into clusters (groups) those objects that, when combined into a single cluster, ensure the minimization of the sum of squares of the deviations of all elements from the center of gravity of the new cluster they formed. Thus, it can be said that this method involves grouping those objects that cause the smallest increase in variance in all the clusters formed, and thus ensure the greatest possible homogeneity of the clusters formed (Gatnar, Walesiak, 2004). The clustering procedure was preceded by standardization of variables, available in the Statistica 13 package, and was carried out according to the formula (Zalewska, 2017):

$$u_{ij} = \frac{x_{ij} - \bar{x}_j}{S_{x_j}},$$

where:
x_{ij} - empirical *value of the j-th* variable in the i-th country,

$\bar{X}_j$ - arithmetic mean of the *j-th* variable,

S_{xj} - standard deviation of the *j-th* variable.

As a measure of similarity between objects, the Euclidean distance, calculated according to the formula (Zalewska, 2017), is most often used here:

$$d(x,y) = \sqrt{\sum_{i=1}^{p} (X_i - y_i)^2}$$

Euclidean distances are heavily influenced by differences in units between the dimensions from which distances are calculated. Therefore, the standardization of variables carried out beforehand is necessary in order to have data of comparable scale (Statsoft, 2024). The result of the study is a dendrogram, which is a graphical interpretation of the results obtained - see Figure 1.

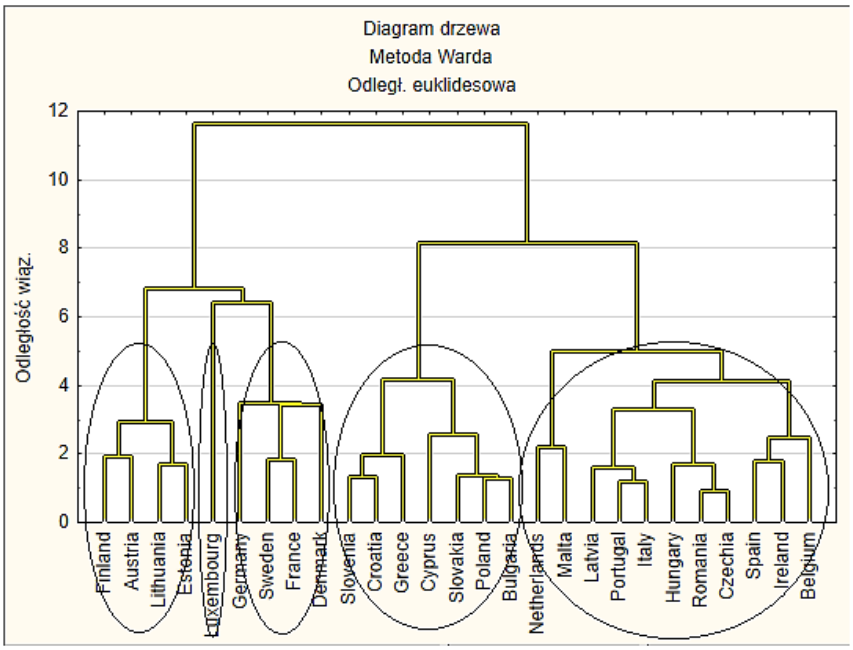

Figure 1. Dendrogram of hierarchical cluster analysis using Ward's method.

Source: own elaboration.

An important part of the cluster analysis is the dendrogram cutoff, allowing to determine the number of clusters in the analyzed study. The following six groups of countries were obtained from the Ward clustering procedure based on the evaluation of the amalgamation curve (see Figure 2):

A Luxembourg.

B Austria, Estonia, Finland, Lithuania.

C Denmark, France, Germany, Sweden.

D Bulgaria, Croatia, Cyprus, Greece, Poland, Slovakia, Slovenia.

E Belgium, Czech Republic, Hungary, Ireland, Italy, Latvia, Malta, Netherlands, Portugal, Romania, Spain.

Hierarchical methods of cluster analysis, which include the Ward method applied in the study, allow to divide objects into groups, but do not give a clear answer to the question how to determine their optimal number. The basis for assessing the correctness of the clustering carried out is the analysis of homo- and heterogeneity of the groups. In order to be able to check the correctness of the obtained solution, the evaluation carried out in terms of homogeneity of groups and diversity between them, can be carried out on the basis of simple measures. These include such parameters as the average or maximum distance between objects in a given cluster, the average or minimum distance between groups.

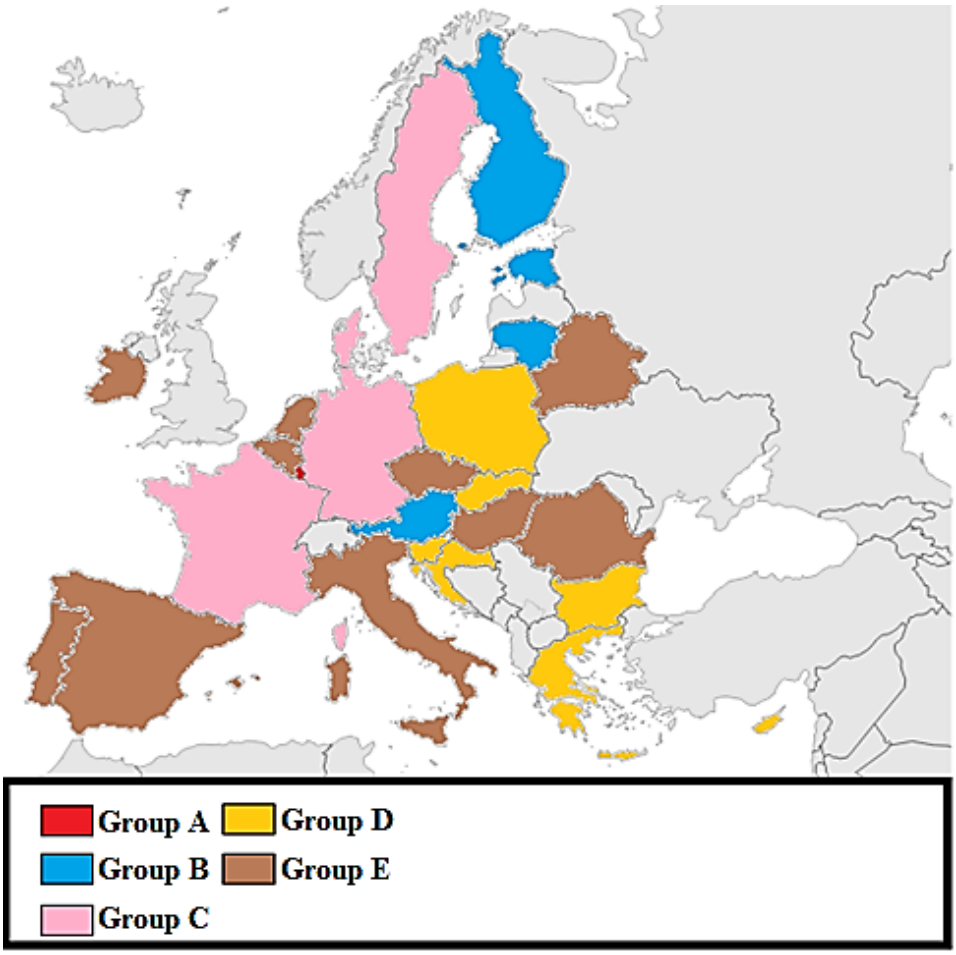

Figure 2. Grouping EU countries based on their environmental policies using the Ward method (2018-2021).

Source: own elaboration.

However, a fundamental shortcoming of these measures is the difficulty of establishing a critical value to determine what results can be considered satisfactory. Among the measures for assessing the homogeneity of the groups formed, measures based on the analysis of variance, such as the F test of the variance quotient, attract attention first of all. The results of this test indicate that of the six variables analyzed, four (at a significance level of 0.05) significantly differentiate the separated groups of countries - see Table 6.

Table 6.
F-test values and mean values of variables in groups of countries separated by Ward's method

	The mean values of the variables in each group						
	Groups						
Diagnostic feature	**A**	**B**	**C**	**D**	**E**	**F-test value**	**p-value**
X_1	0,186	0,16	0,247	0,152	0,187	2,61970187	0,062656
X_2	1,57%	2,38%	2,31%	3,16%	2,36%	2,74071413	0,054527
X_3	2,15%	1,04%	1,19%	1,70%	2,00%	2,96933914	0,042070
X_4	55,80%	20,13%	23,83%	38,44%	21,96%	16,1598749	0,000003
X_5	65,83	13,35	72,74	0,57	8,79	28,6266701	0,000000
X_6	6,77%	4,32%	2,67%	2,13%	1,99%	23,8148334	0,000000

Source: own elaboration.

The country grouping shows that in Luxembourg (Group A) in 2018-2021, the average price of electricity was 1.8% higher than the average, the share of revenue from environmental taxes in GDP was 38.2% lower than the EU average, budget expenditures on environmental protection accounted for 29% more of total budget expenditures as in the EU countries on average, the areas covered by environmental protection are 44.2% smaller than the average for all the countries surveyed. Luxembourg is a country that is committed in the implementation of a $100 billion per year project to combat climate change. Per capita contributions to this effort are nearly 348% of the average. It is also a country where employment in the environmental sector is 255.5% of the average. This is a cluster that diverges from the others both in terms of numbers (it is the least numerous) and values of individual variables. This is primarily due to the peculiarities of the country of Luxembourg. It is a country with the highest value of GDP per capita at purchasing power parity in the EU.

In Group B (Austria, Estonia, Finland and Lithuania) - average electricity prices for households during the period under review were on average 12.6% lower than the EU average. The share of environmental tax revenues in GDP was 6.3% lower than the average among the countries studied. Budget expenditures on environmental protection in the countries of group B were, on average, 3.8% higher than the average among the surveyed countries. Protected areas are 27.8% less compared to the average of the 27 countries in the community. Group B countries are far less committed to the $100 billion initiative for the environment - their per capita contributions are almost 30% lower than the average. Employment in the environmental sector, on the other hand, is significantly higher as the for most EU-27 countries - it is more than 163% of the average. Group B countries are not homogeneous in terms of the size of GDP per capita at purchasing power parity. They are united by the fact that these countries joined the structures of the European Union in 1995 and 2004. They are countries with a relatively small area (only Finland is larger) and have relatively small population.

In cluster C (Denmark, France, Germany and Sweden), electricity prices for households were 35% higher than the average for the whole community from 2018 to 2021. The share of environmental taxes in the structure of budget revenues was nearly 10% lower than the average for the period under review, while budget expenditures on environmental protection were 20% higher compared to the average for all countries surveyed. The area of the country covered by environmental protection accounted for in Cluster C countries 13.4% less than the EU-27 average during the period. Countries in cluster C are heavily involved in the $100 billion per year initiative for climate protection. Their per capita contributions to this goal are nearly 385% of the average. Countries within Cluster C are characterized by high level of GDP per capita at purchasing power parity - all above the EU average - Denmark, Sweden and Germany are among the most prosperous European countries.

In cluster D (Bulgaria, Croatia, Cyprus, Poland, Slovakia, Slovenia), electricity prices were 16.6% lower than the average for all countries EU over the 2018-2021 period. The share of budget revenues from environmental taxes in total revenues was more than 24% higher than

the average, and the share of environmental expenditures in total expenditures was also higher - nearly 170% of the average. Unlike the other clusters, Group D is characterized by an above-average share of protected areas in the country's total area - in the period under review it was 39.8% higher than the average. In terms of per capita contributions relating to the $100 billion per year initiative for climate protection, countries in cluster D were characterized by very low values of this indicator - it was only 3% of the EU average. Compared to clusters A, B and C, countries in cluster D also had lower than average employment in the environmental sector. All countries forming cluster D joined the European Union relatively recently, in the 21st century, and are characterized by GDP per capita at purchasing power parity below the EU average.

The last of the designated clusters - E (Belgium, Czech Republic, Hungary, Ireland, Italy, Latvia, Malta, Netherlands, Portugal, Romania and Spain) is the most numerous group - 11 and the least homogeneous. This cluster was characterized by a slightly higher-than-average household electricity price (by 2.3%), comparable with clusters B and C shares of environmental tax revenues in generated GDP (92.9% of the average). Expenditures on environmental protection in countries in cluster E were double the EU-27 average in their budgets. The share of protected areas in the total area of the country was 20.1% lower than the average in the countries constituting cluster E. These countries were also characterized by significantly lower contributions under the $100 billion per year initiative to combat climate change (46.4% of the average), as well as by 25% lower employment than the average in the community countries in the environmental sector.

5. Summary

The environmental policies of the European Union countries in 2018-2021 were very heterogeneous. In order to be able to group countries in this category, the author selected variables on the basis of data collected by Eurostat, and then applied the Ward method, which is one of the methods of cluster analysis. The aim of the study was to create homogeneous groups with similar characteristics of applied environmental policies - fiscal and non-fiscal. Using the method, 27 countries were divided into 6 clusters. However, the question of the degree of homogeneity of the obtained groups of countries remains a subject of discussion. The results of the F test of the variance quotient show that it was not possible to achieve complete homogeneity of the groups formed. In practice, it is very difficult to meet this criterion for all variables, and in turn, the separation of more groups of countries would contradict the assumptions of the cluster analysis method. The selection of a set of diagnostic variables, which is always a subjective choice, also remains an issue. Due to the existence of a gap in Polish literature on environmental policy, the author plans to conduct further research and expand the presented issues using other statistical methods.

References

1. Albulescu, C.T., Boatca-Barabas, M.E., Diaconescu, A. (2022). The asymmetric effect of environmental policy stringency on CO_2 emissions in OECD countries. *Environmental science and pollution research international*, *No. 29(18),* pp. 27311-27327, doi: 10.1007/s11356-021-18267-8
2. Almeida Neves, S., Cardoso Marques, A., Patrício, M. (2020). Determinants of CO_2 Emissions in European Union Countries: Does Environmental Regulation Reduce Environmental Pollution? *Economic Analysis and Policy*, *Vol. 68,* pp. 114-125. Retrieved from: https://www.sciencedirect.com/science/article/pii/S0313592620304161, 12.04.2025.
3. Baran, A.(2024). Zarządzanie ochroną środowiska w Unii Europejskiej – przegląd działań w zakresie polityki środowiskowej. *Akademia Zarządzania*, *Vol. 8, No. 4,* pp. 180-197, doi: 10.24427/az-2024-0069
4. *Eurostat Database*. Retrieved from: https://ec.europa.eu/eurostat/data/database, 12.04.2025.
5. Gatnar, E., Walesiak, M. (2004). *Metody statystycznej analizy wielowymiarowej w badaniach marketingowych.* Wrocław: Wydawnictwo Akademii Ekonomicznej im. Oskara Langego we Wrocałwiu.
6. Godawska, J. (2024a). Does environmental policy stringency matter for eco-innovation? Evidence from the EU countries. *International Entrepreneurship Review*, *10(1),* 69-82. https://doi.org/10.15678/IER.2024.1001.05
7. Godawska, J. (2024b). The impact of environmental taxes on the level of NOx and SOx emissions. *Economics and Environment*, *Vol. 89, No. 2,* 744. https://doi.org/10.34659/eis.2024.89.2.744
8. Grabiński, T., Wydymus, S., Zeliaś, A. (1989). *Metody taksonomii numerycznej w badaniu zjawisk społeczno-gospodarczych*. Warszawa: PWN.
9. Hu, Y., Bai, W., Farrukh, M., Koo, C.K. (2023), How does environmental policy uncertainty influence corporate green investments? *Technological Forecasting and Social Change*, *vol. 189(C),* doi: 10.1016/j.techfore.2023.122330
10. Kurrer, C., Petit, A. *Polityka ochrony środowiska: ogólne zasady i podstawowe ramy*. Retrieved from: https://www.europarl.europa.eu/factsheets/pl/sheet/71/polityka-ochrony-srodowiska-ogolne-zasady-i-podstawowe-ramy, 10.04.2024.
11. Kwon, Y., Lee, H., Lee, H. (2018). Implication of the cluster analysis using greenhouse gas emissions of Asian countries to climate change mitigation. *Mitigation and Adaptation Strategies for Global Change*, *Vol. 23,* pp. 1225-1249, doi: 10.1007/s11027-018-9782-3
12. Maruszkin, R., Bednarek, J. (2024). Ochrona klimatu w prawie Unii Europejskiej i w prawie polskim. *Przegląd Prawa Publicznego*, *Vol. 5,* pp. 50-68.

13. Paradowska, M., Platje, J., Suchecka, A. (2024). Polish climate policy in the opinion of young Poles - a pilot survey. *Economics and Environment*, *Vol. 87, No. 4,* pp. 1-22, doi: 10.34659/eis.2023.87.4.669
14. StatSoft. *Internetowy Podręcznik Statystyki*. Retrieved from: https://www.statsoft.pl/textbook/stathome.html, 12.01.2025.
15. Szymański, W., Węgrzyn, J. (2024). Fiscal efficiency of the green transformation of the tax system on selected examples of European Union Member States. *Journal of Modern Science*, *Vol. 55, No. 1,* pp. 688-709, doi: https://doi.org/10.13166/jms/185547
16. Tomaszewski, K. (2024). Global Climate Policy and Religion–the Case of Pope Francis. *Studia Politologiczne*, *Vol. 74*, pp. 343-363, doi: 10.33896/SPolit.2024.74.19
17. Wolde-Rufael, Y., Mulat-Weldemeskel, E. (2021). Do environmental taxes and environmental stringency policies reduce CO_2 emissions? Evidence from 7 emerging economies. *Environmental science and pollution research international*, *Vol. 28, No. 18,* pp. 22392-22408, doi: https://doi.org/10.1007/s11356-020-11475-8
18. Zalewska, E. (2017), Zastosowanie analizy skupień i metody porządkowania liniowego w ocenie polskiego szkolnictwa wyższego. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, No. 469,* pp. 234-242, doi: 10.15611/pn.2017.469.24
19. Zhang, D., Zheng, M., Feng, G., Chang, C. (2022). Does an environmental policy bring to green innovation in renewable energy? *Renewable Energy*, *Vol. 195,* pp. 1113-1124, doi: 10.1016/j.renene.2022.06.074