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ANALYSIS OF SELECTED COUNTRIES ACCORDING TO THEIR ENERGY CONSUMPTION BY CLUSTER ANALYSIS K-MEANS METHOD*

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ABSTRACT

In this study, countries (Australia, Austria, Azerbaijan, Belgium, Brazil, Bulgaria, Canada, China, Chile, Colombia, Denmark, Egypt, Finland, France, Germany, Greece, Hungary, India, Indonesia, Iran, Iraq, Italy, Japan, Kazakhstan, Luxembourg, Mexico, New Zealand, the Netherlands, Norway, Pakistan, Poland, Portugal, Russia, Spain, Sweden, Switzerland, Thailand, Türkiye, the United Kingdom, the United States, and Uzbekistan) were clustered based on their energy consumption for the years 2000 and 2021. In line with the objectives of the study, data on nuclear energy, coal consumption, oil consumption, natural gas consumption, hydropower consumption, and renewable energy consumption were used to represent energy consumption.

The clustering analysis revealed differences between countries in the clusters formed between 2000 and 2021. The transition of countries such as Iran, the Netherlands, Mexico, and Luxembourg from Cluster 1 in 2000 to Cluster 2 in 2021 illustrates the complexity of changes in energy consumption patterns. Factors underlying these changes include changes in energy policies, economic conditions, international relations, and technological advances. Similarly, the transition of countries such as Canada, Germany, Italy, Spain, and the United Kingdom from Cluster 2 in 2000 to Cluster 1 in 2021 can be attributed to various factors such as changes in energy policies, economic growth or stagnation, technological progress, shifts in international trade relations, and environmental considerations.

Keywords: *Tourism demand, Economic freedom, Panel data analysis*

JEL Codes: *L83, E02, C23*

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KÜMELEME ANALİZİ K-ORTALAMA YÖNTEMİ İLE SEÇİLİ ÜLKELERİN ENERJİ TÜKETİMLERİNE GÖRE İNCELENMESİ

ÖZET

Bu çalışmada, 2000 ve 2021 yılları için enerji tüketimlerine göre ülkeleri (Avustralya, Avusturya, Azerbaycan, Belçika, Brezilya, Bulgaristan, Kanada, Çin, Şili, Kolombiya, Danimarka, Mısır, Finlandiya, Fransa, Almanya, Yunanistan, Macaristan, Hindistan, Endonezya, İran, Irak, İtalya, Japonya, Kazakistan, Lüksemburg, Meksika, Yeni Zelanda, Hollanda, Norveç, Pakistan, Polonya, Portekiz, Rusya, İspanya, İsveç, İsviçre, Tayland, Türkiye, Birleşik Krallık, Amerika Birleşik Devletleri ve Özbekistan) kümelemek amaçlanmıştır. Çalışmanın hedefi doğrultusunda, enerji tüketimini temsil etmek için nükleer enerji, kömür, petrol, doğalgaz, hidroelektrik ve yenilenebilir enerji tüketimi verileri kullanılmıştır.

Kümeleme analizi sonucunda, 2000 ve 2021 yıllarında oluşan kümeler arasında ülkelerde farklılıklar olduğu belirlenmiştir. İran, Hollanda, Meksika ve Lüksemburg gibi ülkelerin 2000'de Küme 1'de yer alırken 2021'de Küme 2'ye geçmeleri, enerji tüketimindeki değişikliklerin karmaşıklığını göstermektedir. Bu değişimlerin nedenleri arasında enerji politikalarının değişmesi, ekonomik koşullar, uluslararası ilişkiler ve teknolojik ilerlemeler yer almaktadır. Kanada, Almanya, İtalya, İspanya ve Birleşik Krallık gibi ülkelerin 2000'de Küme 2'de yer alıp 2021'de Küme 1'e geçmeleri de çeşitli faktörlerin etkisiyle açıklanabilir. Bu faktörler arasında enerji politikalarındaki değişiklikler, ekonomik büyüme veya durgunluk, teknolojik ilerlemeler, uluslararası ticaret ilişkilerindeki değişimler ve çevresel etkiler bulunmaktadır.

Anahtar Kelimeler: *Enerji tüketimi, Kümeleme analizi, Nükleer enerji, Yenilenebilir enerji tüketimi.*

JEL Kodları: *L83, E02, C23.*

1. GİRİŞ

Today, energy use is recognized as an essential part not only for economic growth and industrial production, but also for a number of important factors such as technological development and quality of life (Mishra and Singh, 2023). Energy is a vital requirement for the functioning of modern societies and is necessary for many sectors to continue their activities. However, energy use is not limited to these positive effects. The intensive use of fossil fuels, especially the overuse of traditional energy sources like coal and oil, leads to an increase in greenhouse gases in the atmosphere and climate change. Moreover, limited energy resources and increasing environmental impacts raise concerns about the sustainability of energy consumption. In this context, the efficient and sustainable use of energy resources is of strategic importance on a global scale. Efficient energy use can ensure longer-term utilization of resources and reduce environmental impacts by stabilizing energy consumption (Bragg-Sitton et al., 2020).

The using different energies has various economic, environmental and social impacts on a global scale and each energy source has its own advantages and challenges (Zawaydeh, 2017). The intensive consumption of traditional energy sources, especially fossil fuels, is a major concern that can cause environmental problems and climate change (Singh, 2021). The combustion of fossil fuels like coal, oil and natural gas leads to the release of large amounts of greenhouse gases into the atmosphere and thus to climate change, which is associated with global warming (Yoro and Daramola, 2020; Soeder, 2021). Furthermore, the extraction and processing of fossil fuels can contribute to the destruction of natural habitats, water and soil pollution and biodiversity loss. Therefore, the transition to renewable energy sources is becoming increasingly important. Renewables like wind, solar, hydroelectric, geothermal and biomass are less damaging to the environment and can be supplied in an unlimited or renewable manner. Using renewable energy can reduce greenhouse gas emissions, reduce air and water pollution and contribute to the protection of ecosystems. Moreover, the development and diffusion of renewable energy technologies can increase energy independence and stimulate economic growth. However, the utilization of renewable energy sources can also face some challenges (Husin and Zaki, 2021). For example, renewable resources, such as solar and wind, are naturally variable and intermittently available, which can create occasional mismatches with energy demand. Furthermore, the installation and maintenance of renewable energy technologies are often costly and may require infrastructure investments. Therefore, in order to increase the use of renewable energy sources, emphasis should be placed on infrastructure and technology development as well as policies and incentives.

This study aimed to is to analyze the energy consumption data of selected countries and, based on these data, to identify groups with similar energy consumption habits. The identification of these groups allows us to understand common trends and factors in energy consumption and to better grasp the similarities and differences between various countries. As a result of this analysis, an in-depth understanding of the energy consumption patterns and trends of the identified groups will be developed and this information will contribute to the development of energy policies and the achievement of sustainability goals. For example, successful practices of countries with similar energy consumption patterns can be learnt from and this information can be taken into account in the policy-making processes of other countries. In addition, this study will provide important guidance to decision-makers and experts to determine energy policies more effectively. Analyses on the identified groups can help us understand and optimize various dimensions of energy policies, which can contribute to making energy use more sustainable and reducing environmental impacts..

2. LITERATURE REVIEW

In the applied research literature, it can be observed that there is a significant diversity of studies related to energy resources. There is a considerable amount of research on the link between total energy use and economic growth. These are then followed by studies on coal, nuclear, natural gas, oil and renewable energy use.

Tiwari et al. (2015) analyzed the relationship between economic growth and energy production in 12 sub-Saharan African countries from 1971 to 2011, using hidden cointegration and linear cointegration tests. They found that for the first subset of countries, causality exists from energy consumption to economic growth, while for the second subset, causality exists from economic growth to energy consumption. Aydemir et al. (2020) examined the relationship between income and energy consumption in N11 countries (Bangladesh, Egypt, Indonesia, Iran, South Korea, Mexico, Nigeria, Pakistan, Philippines, Türkiye and Vietnam) for the period 1990-2015. They applied the Emirmahmutoğlu Köse panel causality test in their study. The analysis showed that the direction of causality for the N11 countries was from energy consumption to growth.

Menyah and Wolde Rufael (2010) examined the interaction between nuclear energy consumption and economic growth in the United States for the period 1960-2006 using the Granger causality test (Toda Yamamoto version). The analysis revealed a bidirectional Granger causality between nuclear energy consumption and economic growth, indicating support for the feedback hypothesis. In their study, Şimşek and Aydın (2018) investigated the interaction between nuclear energy consumption and economic growth in developed countries for the period 1997-2016 using the panel data analysis method. The analysis concluded that nuclear energy consumption has a positive impact on economic growth, and a one-way causality from nuclear energy consumption to economic growth was detected. The study supports the growth hypothesis.

Li and Leung (2012) provided evidence for the validity of the feedback hypothesis in coastal and central provinces and the conservation hypothesis in western provinces for 23 Chinese provinces for the period 1985-2008. Oğuz et al. (2013), using the Hatemi-J (2012) causality test for the period 1980-2006, failed to identify a causal relationship between economic growth and coal consumption, suggesting the validity of the neutrality hypothesis in Türkiye. Moreover, Eygu and Soğukpınar (2023) investigated the economic growth and the utilization of renewable resources in the production of electrical energy with augmented ARDL with Türkiye's recent policies. Aktaş (2017), using the error correction model-based Granger causality, presented evidence for the existence of a reciprocal causality between economic growth and coal consumption for the period 1970-2014. Therefore, according to Aktaş (2017), the feedback hypothesis is valid in Türkiye.

Ewing et al. (2007), for the United States in the period 2001-2005, using the GFEVD method and industrial production and natural gas consumption variables, observed a relationship between natural gas consumption and GDP. Reynolds and Kolodziej (2008), for the Soviet Union in the period 1928-2003, using the Granger causality method, found a relationship from natural gas consumption to GDP. Gülay and Pazarlıoğlu (2016) focus on quarterly data in their study covering the period 1984-2010 in

Türkiye, using the Gregory and Hansen cointegration analysis that allows for structural breaks. The results of the analysis indicate a negative relationship between economic growth and real crude oil prices, as well as between economic growth and the real exchange rate. Cheng-Yih and Chen-Jung (2018) analyzed the changes in the intensity of crude oil imports in the Taiwanese economy between 1981 and 2016, noting that Taiwan is highly dependent on exports and about 98% dependent on imports for energy consumption. The results show that the intensity of crude oil imports is highest in the oil and gas sector. Changes in the factors affecting the intensity of imported crude oil are mainly attributed to the domestic production structure and final demand structure.

Zafar and Mohammad (2018) examine the long-term relationship between economic growth and factors such as petroleum exports, imports and government consumption expenditure in Saudi Arabia. Their study shows that economic growth is significantly related to petroleum exports, imports, and government consumption expenditures in the long run. They suggest intensive efforts to monitor and regulate imports, diversify the economic base through exports, and promote import-substitution industries in the country. Koyuncu and Karabulut (2021) examine the relationship between renewable energy, ecological footprint and economic growth in Türkiye using data from 1961 to 2015. Their analysis, conducted using the TAR model, shows that the ecological footprint has a positive impact on economic growth. In addition, they find that electricity production has a negative impact on economic growth in the first regime period and a positive impact in the second regime period.

Demir and Görür (2020) analyzed the relationship between the consumption of various types of energy and economic growth in 36 OECD countries using the Westerlund (2007) panel cointegration test. The results show that there is cointegration between energy consumption and economic growth. As a result of the long-run cointegration test, it is determined that there is a positive relationship between hydroelectric and renewable energy consumption and economic growth, while there is a negative relationship between thermal energy consumption and economic growth. Özen et al. (2023) analyzed the effects of hydroelectricity use, coal use, oil use and renewable energy use on agricultural land use in Türkiye by ARDL bounds test. According to the results obtained, a significant relationship was found between coal use and oil use and the dependent variable of agricultural land use. On the other hand, there is no significant relationship between hydroelectricity use and renewable energy use and agricultural land use. Demir et al. (2023) analyzed the effects of coal, natural gas, hydroelectricity and renewable energy consumption on CO_2 emissions in Türkiye using the ARDL bounds test. According to the ARDL test, it is determined that the effect of coal, natural gas and renewable energy consumption on CO_2 emission is significant, but the effect of hydroelectric energy consumption is not significant. It is also observed that renewable energy consumption decreases CO_2 emission and the other three variables increase the emission.

3. MATERIAL AND METHOD

The main aim of this study is to cluster countries based on their energy consumption for the years 2000 and 2021. The countries included in the analysis are Australia, Austria, Azerbaijan, Belgium, Brazil, Bulgaria, Canada, China, Chile, Colombia, Denmark, Egypt, Finland, France, Germany, Greece, Hungary, India, Indonesia, Iran, Iraq, Italy, Japan, Kazakhstan, Luxembourg, Mexico, New Zealand, Netherlands, Norway, Pakistan, Poland, Portugal, Russia, Spain, Sweden, Switzerland, Thailand, Türkiye, the United Kingdom, the United States, and Uzbekistan. Detailed information regarding the variables considered in the empirical model is provided in Table 1.

Table 1 Definition of series

Symbol	Variables	Source
lnnuclear	Nuclear Energy Consumption	British Petroleum Stats (BP)
lncoal	Coal Consumption	British Petroleum Stats (BP)
lnoil	Oil Consumption	British Petroleum Stats (BP)
lnnaturalgas	Natural Gas Consumption	British Petroleum Stats (BP)
lnhydroelectric	Hydropower Consumption	British Petroleum Stats (BP)
lnrenewable	Renewable Energy Consumption	British Petroleum Stats (BP)

In the study, variables were used after taking their logarithms. The use of logarithmic transformations assists in correcting the distribution of variables in the dataset and obtaining more robust results during the analysis process. Logarithmic transformation helps to make the distribution of variables in the dataset closer to a normal distribution and ensures that various analysis techniques meet their assumptions. This enables statistical analysis and modeling processes to become more reliable and effective. Particularly in methods like regression analysis, the logarithmic transformation of variables allows errors to be closer to a normal distribution and facilitates better model fit. Therefore, logarithmic transformation is commonly used to correct the distribution of variables in the dataset and to obtain more reliable results during the analysis process. Descriptive statistics and a correlation matrix for the variables used in the year 2000 are provided in Table 2.

Table 2. Descriptive statistics and correlations (2000)

	lnnuclear	lncoal	lnoil	lnnaturalgas	lnhydroelectric	lnrenewable
Mean	2.127	2.260	3.460	2.693	1.400	-0.470
Median	2.388	2.054	3.446	2.653	1.523	-0.357
Maximum	5.190	6.602	6.784	6.397	4.391	2.873
Minimum	-1.609	-2.303	1.410	-0.357	-2.659	-2.303
Std. Dev.	1.627	1.850	1.207	1.390	1.794	1.278
Skewness	-0.182	0.227	0.448	0.353	-0.428	0.302
Kurtosis	2.910	3.189	2.759	3.236	2.778	2.791
Jarque-Bera	0.123	0.393	1.476	0.950	1.235	0.528
Probability	0.940	0.821	0.478	0.621	0.539	0.767
Correlation Matrix						
lnnuclear	1.000					
lncoal	0.330	1.000				
lnoil	0.446	0.873	1.000			
lnnaturalgas	0.544	0.738	0.858	1.000		
lnhydroelectric	0.042	0.329	0.460	0.173	1.000	
lnrenewable	0.414	0.543	0.641	0.547	0.608	1.000

Upon examining the descriptive statistics provided in Table 2, it is observed that, based on the mean and median values, the variable of oil consumption has the highest value. Standard deviation values measure the extent of spread in the distribution of a dataset. A higher standard deviation indicates that the data is spread out more widely around the mean, while a lower standard deviation suggests a narrower distribution. Skewness and kurtosis are statistical measures indicating the symmetry of a data set's distribution and the weight of its tails. If skewness is negative, the distribution is right-skewed (the left tail is longer); if positive, it is left-skewed (the right tail is longer); and if it is 0, it indicates a symmetric distribution. Kurtosis, on the other hand, indicates how peaked or flat the distribution is. The Jarque-Bera test and the associated probability values suggest that all variables exhibit a normal distribution. When examining the correlation matrix, various relationships among the variables are observed. There is a positive correlation between variables. Descriptive statistics and a correlation matrix for the variables used in 2021 are provided in Table 3.

Table 3. Descriptive statistics and correlations (2021)

	lnnuclear	lncoal	lnoil	lnnaturalgas	lnhydroelectric	lnrenewable
Mean	-0.971	-0.978	0.291	-0.139	-1.328	-1.183
Median	-0.892	-1.470	0.322	0.231	-1.371	-1.189
Maximum	2.001	4.456	3.564	3.393	2.505	2.426
Minimum	-3.507	-4.605	-2.207	-3.507	-4.605	-3.912
Std. Dev.	1.451	1.971	1.314	1.609	1.587	1.484
Skewness	0.250	0.727	0.391	-0.030	0.213	0.320
Kurtosis	2.673	3.167	2.972	2.560	2.767	2.782
Jarque-Bera	0.312	3.304	1.047	0.336	0.353	0.724
Probability	0.855	0.191	0.592	0.845	0.837	0.696
Correlation Matrix						
lnnuclear	1.000					
lncoal	0.576	1.000				
lnoil	0.581	0.829	1.000			
lnnaturalgas	0.389	0.603	0.854	1.000		
lnhydroelectric	0.549	0.666	0.651	0.476	1.000	
lnrenewable	0.557	0.448	0.490	0.206	0.464	1.000

When examined based on the mean and median values, it is observed that the variable of oil consumption has the highest mean and median values in Table 3. This indicates that oil consumption is more commonly used compared to other energy sources, and typically, the mean and median of consumption in the dataset are higher. When examining the correlation matrix, various relationships among the variables are observed. There is a positive correlation between variables.

3.1. Theoretical Framework of Cluster Analysis

The concept of cluster analysis was first introduced to the literature by Tyron in 1939 (Yılmaz and Temurlenk, 2005). One of the methods used for the analysis of multivariate data is cluster analysis. Unlike classical methods, cluster analysis provides benefits for investigating and interpreting relationships between two or more variables. Cluster analysis is commonly used as a multivariate data analysis technique, especially in studies that classify grouped data based on similarities. In other words, cluster analysis can be described as a technique that generates classifications from initially unclassified data (Everitt, 1980). The clusters resulting from the clustering method form a highly similar (homogeneous) structure within themselves and a different (heterogeneous) structure among themselves (Kılınç and Eygü, 2018). Cluster analysis techniques are a useful summary tool for data analysis in different situations. Researchers can utilize cluster analysis for purposes such as investigating natural groupings in data, simplifying the explanation of a large dataset, and forming hypotheses that can be tested on future samples (Everitt, 1980).

3.2. Methods Used in Cluster Analysis

After the researcher completes the data entry and obtains the distance matrix, the second stage involves determining which clustering analysis method to use. There are numerous methods available for cluster analysis. We can categorize these methods into two main headings: hierarchical clustering methods and non-hierarchical clustering methods, which are the most well-known and accepted (Tatlıdil, 2002).

3.3. Hierarchical Clustering Methods

Hierarchical clustering is a clustering technique used when there is no prior knowledge about the number of clusters. Researchers typically employ hierarchical clustering methods, especially in samples with fewer than 250 observations (Govender and Sivakumar, 2020; Mulla and Demir, 2023). There are two methods in hierarchical clustering analysis: divisive and agglomerative. The methods used in agglomerative hierarchical clustering include single linkage, complete linkage, average linkage, and Ward's method.

3.4. Non-hierarchical Clustering Methods

In non-hierarchical clustering methods, the number of clusters is predetermined, so determining the number of clusters does not pose a problem for the researcher. The determination of the number of clusters proceeds based on the researcher's knowledge and experience during the application of the technique (Kangallı et al., 2016; İşleyen, 2021).

To successfully apply clustering analysis and obtain accurate results, researchers must pay attention to two important factors. Firstly, the researcher must select significant variables through analysis. Secondly, determining the number of clusters is crucial (Tatlıdil, 2002). In non-hierarchical clustering methods, the number of clusters must be predetermined. Therefore, researchers can resort to different methods to decide on the number of clusters. The most commonly used method for determining the number of clusters is generally calculated as follows: To indicate the number of individuals to be clustered, k is approximately calculated as $\cong \sqrt{\frac{n}{2}}$. Another method used by researchers is proposed by Mariot, where the value of M indicates the number of clusters when it represents the true number of clusters; $M = k^2|W|$, where W is the within-group sum of squares matrix (Ada Altun, 2011). Non-hierarchical clustering methods can be applied using various techniques. The two most commonly used methods are the k-means developed by Mac Queen and the maximum likelihood techniques (Tatlıdil, 2002).

3.4.1. K-Means Technique

The k-means technique, which is one of the non-hierarchical clustering methods, is used when the researcher has prior knowledge about the number of clusters and decides that the number of clusters (k) is meaningful for the application (Uzgören et al., 2013; İşleyen, 2021; Mulla and Demir, 2023). When applying the technique, individuals are divided into k clusters in such a way that the within-cluster sum of squares is minimized. That is, if $x_1, x_2, \dots, x_n$ are observation vectors with p variables, considered as points in multidimensional space X, and $a_{\iota n}, \dots, a_{kn}$ are selected as cluster centers for each group member in the same space, then,

$$W_n = \frac{1}{n}\sum_{i=1}^{n} \min_{1\le j\le k} \left\| x_i - a_{jn} \right\|^2 \quad (1)$$

According to the rule, individuals are classified into the nearest cluster (Tatlıdil, 2002).

The k-means technique does not require a rule such as an equal number of members in each cluster, as the number of clusters can be determined by the researcher (Uzgören et al., 2013). Tatlıdil (2002) summarized the operation of the technique in computer algorithms as follows:

1. The first k observations are each considered a cluster consisting of a single observation.
2. The remaining n observations are assigned to the cluster with the closest mean. After each assignment, cluster means are recalculated.
3. After all observations have been assigned to clusters, the last observation is re-assigned based on the cluster means obtained.
4. Step 3 continues to be repeated until there is no transfer of observations between clusters compared to the previous clustering.

In the k-means technique, two significant disadvantages can be encountered. Firstly, it is quite difficult for the researcher to know the number of clusters, which may require repeating the analysis multiple times. Secondly, the technique can be sensitive to the initial selection of cluster centers (Uzgören et al., 2013; İşleyen, 2021).

4. ANALYSIS AND FINDINGS

For the data from the year 2000, the dendrogram obtained using the average linkage technique is presented in Figure 1, the agglomeration schedule in Table 4, and the resulting cluster structure in Table 5.

According to the agglomeration schedule, countries most similar to each other formed a group in the first stage. It can be observed from the merged cluster column that the 9th (Chile) and 10th (Colombia) countries are the closest to each other. The coefficients column indicates the distance between observations, or the squared Euclidean distance, which is found to be 0.554 for Chile and Colombia, resulting in the formation of the first group. Subsequently, in the same group, the 2nd observation unit, Austria, and in the 9th stage, the 29th unit, Norway, were included, and the clustering process continued until 2 clusters remained.

Figure 1. Dendrogram Showing the Clustering of Countries for the Year 2000 Using the Average Linkage Technique

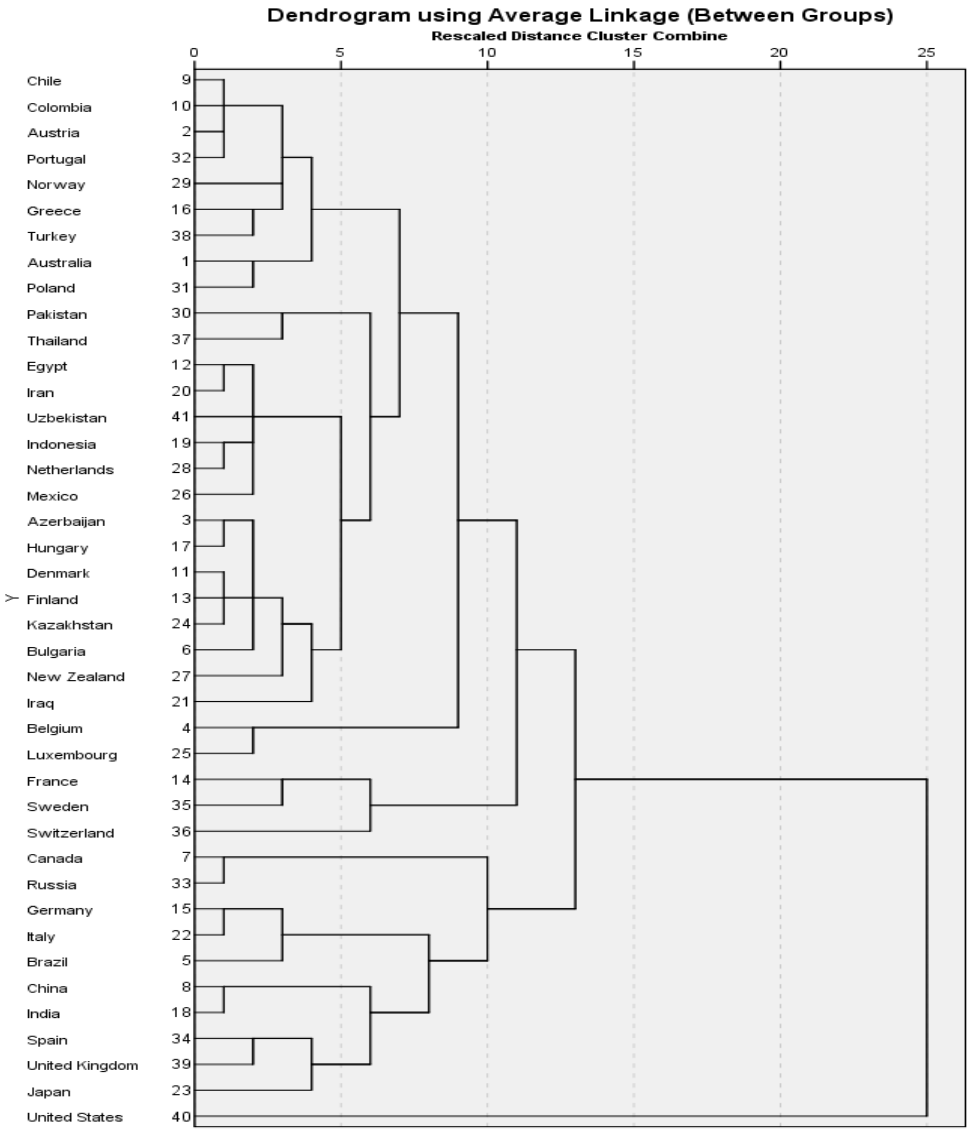

Table 4. Cluster Analysis Results For 2000

Stage	Cluster Combined		Coefficients	Cluster Combined		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	9	10	0.554	0	0	9
2	19	28	0.619	0	0	14
3	11	13	0.685	0	0	10
4	3	17	0.720	0	0	16
5	12	20	1.016	0	0	13
6	2	32	1.332	0	0	9
7	8	18	1.387	0	0	31
8	15	22	1.564	0	0	25
9	2	9	1.642	6	1	21
10	11	24	1.675	3	0	16
11	7	33	1.688	0	0	37
12	16	38	1.779	0	0	26
13	12	41	1.790	5	0	20
14	19	26	1.797	2	0	20
15	1	31	2.201	0	0	27
16	3	11	2.254	4	10	17
17	3	6	2.328	16	0	23
18	4	25	2.682	0	0	36
19	34	39	2.708	0	0	28
20	12	19	2.869	13	14	30
21	2	29	3.015	9	0	26
22	30	37	3.438	0	0	32
23	3	27	3.440	17	0	29
24	14	35	3.670	0	0	33
25	5	15	3.768	0	8	35
26	2	16	3.941	21	12	27
27	1	2	5.206	15	26	34
28	23	34	5.305	0	19	31
29	3	21	5.388	23	0	30
30	3	12	5.501	29	20	32
31	8	23	6.854	7	28	35
32	3	30	7.466	30	22	34
33	14	36	7.599	24	0	38
34	1	3	8.254	27	32	36
35	5	8	9.334	25	31	37
36	1	4	10.570	34	18	38
37	5	7	12.360	35	11	39
38	1	14	12.844	36	33	39
39	1	5	15.589	38	37	40
40	1	40	31.088	39	0	0

Table 5. Cluster Structure According to Distances (2000)

Cluster 1	Cluster 2
Chile	Canada
Colombia	Russia
Austria	Germany
Portugal	Italy
Norway	Brazil
Greece	China
Türkiye	India
Australia	Spain
Poland	United Kingdom
Pakistan	Japan
Thailand	United States
Eygpt	
Iran	
Uzbekistan	
Indonesia	
Netherlands	
Mexico	
Azerbaijan	
Hungary	
Denmark	
Finland	
Kazakhstan	
Bulgaria	
New Zealand	
Iraq	
Belgium	
Luxembourg	
France	
Sweden	
Switzerland	

When Table 5 is examined, the countries included in Cluster 1 for the year 2000 exhibit diversity in terms of energy consumption and generally have moderately developed or developing economies. Among these countries are several European nations. For instance, countries like Austria, Portugal, Norway, Greece, Denmark, Finland, Belgium, Luxembourg, France, Sweden, and Switzerland have advanced economies and extensive energy infrastructure. These countries can effectively utilize hydroelectric, nuclear, and renewable energy sources. Cluster 1 also includes countries from the Middle East and North Africa. Countries like Iran, Egypt, and Iraq typically have strong economies based on fossil fuels such as oil and natural gas. However, some of these countries also invest in other energy sources like hydroelectric or nuclear power. Many countries from the Asia-Pacific region are also included in Cluster 1. Countries like Türkiye, Indonesia, Pakistan, Thailand, India, Kazakhstan, New Zealand, and Australia are part of this cluster. These countries have access to both renewable energy sources and fossil fuels. Particularly populous countries like India and China are experiencing rapid increases in energy consumption. Additionally, countries from Latin America are represented in Cluster 1 as well. Nations like Chile, Colombia, and Mexico heavily utilize energy sources like hydroelectricity and natural gas. Some also invest in nuclear or renewable energy sources. The majority of these countries diversify their energy consumption profiles and implement various policies and investments to enhance energy security. Overall, they are economically stable and rely on various sources to meet their energy needs. This diversity results in differences in energy consumption profiles and reflects these countries' efforts towards energy transition and sustainability.

Countries included in Cluster 2 for the year 2000 are generally those with larger economies and diverse energy consumption profiles. Among these countries are significant economies such as Canada, Germany, Italy, the United Kingdom, Japan, and the United States. The energy consumption profiles of these countries vary and are typically characterized by high energy demand. Particularly, large economies like the United States and China are known as the countries with the highest energy consumption worldwide. Countries included in Cluster 2 differ in terms of their dependence on energy sources. While countries like Russia have rich energy resources such as natural gas and oil, others like Japan are heavily reliant on nuclear energy. Countries like Germany and Spain are pioneers in investing in renewable energy. The dependency of these countries on energy sources influences their national energy policies and foreign relations. Countries included in Cluster 2 generally have large populations and intense industrial activity. This leads to a high energy demand and an increasing need for various energy sources. Especially countries like China and India have rapidly increasing energy demand due to rapid industrial growth and urbanization. The energy consumption of these countries has a significant impact on global energy markets. The energy policies of countries included in Cluster 2 are typically complex and play a significant role in international energy trade. They are key players in the supply and trade of critical energy sources such as oil and natural gas. The energy policies of these countries are based on various factors, such as national security, economic development, and environmental sustainability. In conclusion, countries included in Cluster 2 are diverse in terms of energy consumption and energy policies and are considered important factors influencing global energy markets. They are recognized as significant players shaping energy transition and sustainability efforts.

For the year 2021, the dendrogram obtained using the average linkage technique is presented in Figure 2, the agglomeration schedule is provided in Table 6, and the resulting cluster structure is shown in Table 7. According to the agglomeration schedule, countries with the highest similarity formed a group in the first stage. It is observed that Italy (22nd) and Türkiye (38th) are the closest countries in the merged cluster. The coefficient column indicates the distance between observations, represented by the Euclidean distance. The coefficient for Italy and Türkiye is calculated as 0.246, leading to the formation of the first group through the merging of these countries. Subsequently, in the same group, Australia (1st) in the 5th stage and Indonesia (19th) in the 8th stage were included, and the clustering process continued until two clusters remained.

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Figure 2. Dendrogram Showing the Clustering of Countries for the Year 2021 Using the Average Linkage Technique

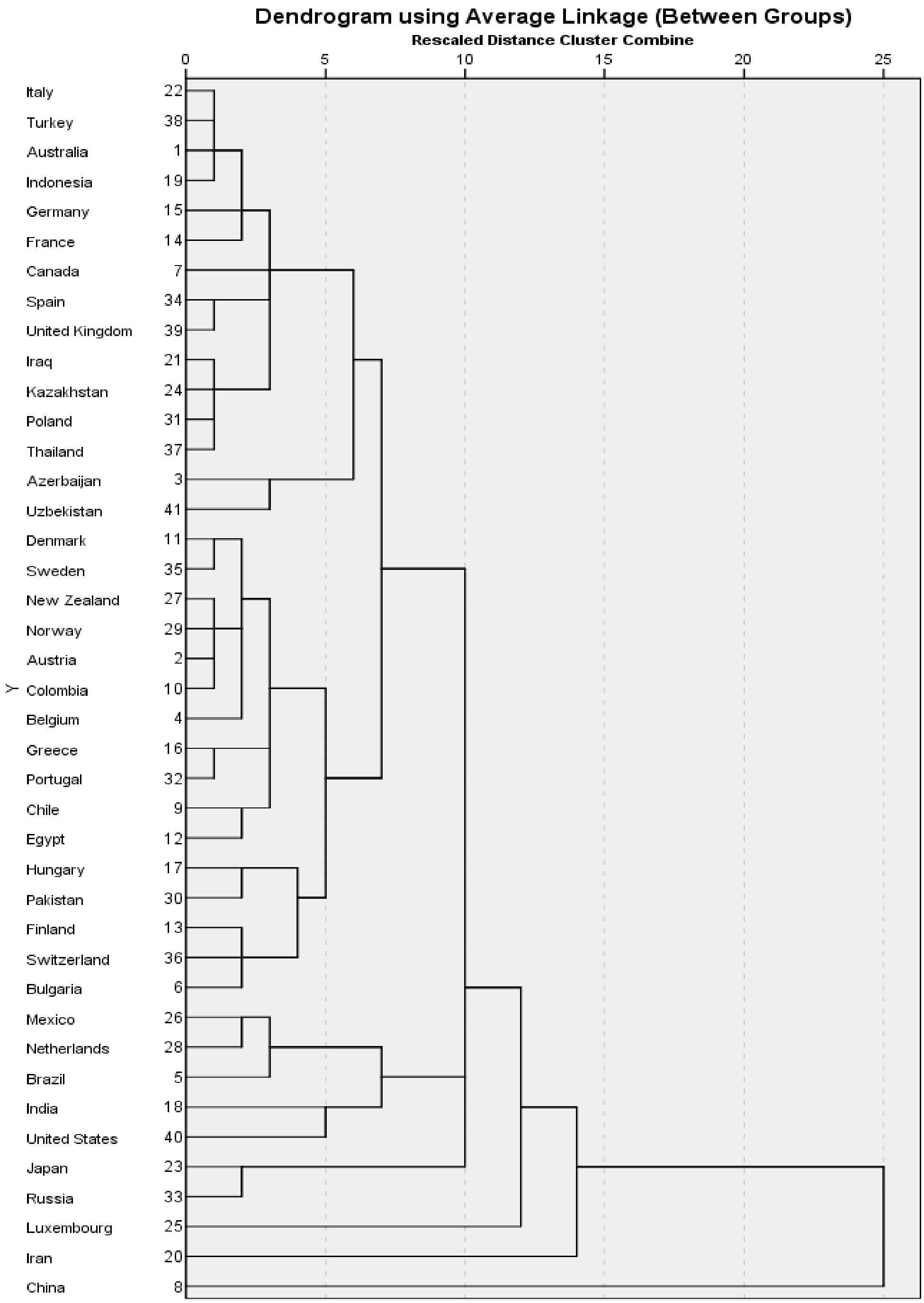

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Table 6. Cluster analysis results for 2021

Stage	Cluster Combined		Coefficients	Cluster Combined		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	22	38	0.246	0	0	5
2	27	29	0.355	0	0	10
3	2	10	0.452	0	0	10
4	21	24	0.711	0	0	12
5	1	22	0.727	0	1	8
6	31	37	0.775	0	0	12
7	11	35	0.946	0	0	22
8	1	19	1.037	5	0	13
9	34	39	1.285	0	0	23
10	2	27	1.383	3	2	16
11	16	32	1.447	0	0	25
12	21	31	1.601	4	6	23
13	1	15	1.817	8	0	15
14	9	12	1.940	0	0	25
15	1	14	2.328	13	0	26
16	2	4	2.425	10	0	22
17	26	28	2.540	0	0	24
18	13	36	2.786	0	0	20
19	17	30	3.141	0	0	30
20	6	13	3.175	0	18	30
21	23	33	3.207	0	0	37
22	2	11	3.221	16	7	28
23	21	34	3.297	12	9	29
24	5	26	3.408	0	17	35
25	9	16	3.485	14	11	28
26	1	7	3.763	15	0	29
27	3	41	3.933	0	0	33
28	2	9	4.379	22	25	32
29	1	21	4.672	26	23	33
30	6	17	5.744	20	19	32
31	18	40	6.381	0	0	35
32	2	6	6.921	28	30	34
33	1	3	8.931	29	27	34
34	1	2	9.662	33	32	36
35	5	18	10.234	24	31	36
36	1	5	14.272	34	35	37
37	1	23	15.096	36	21	38
38	1	25	17.417	37	0	39
39	1	20	21.033	38	0	40
40	1	8	38.221	39	0	0

Table 7. Cluster structure according to distances (2021)

Cluster 1	**Cluster 2**
Italy	Mexico
Türkiye	Netherlands
Australia	Brazil
Indonesia	India
Germany	United States
France	Japan
Canada	Russia
Spain	Luxembourg
United Kingdom	Iran
Iraq	China
Kazakhstan	
Poland	
Thailand	
Azerbaijan	
Uzbekistan	
Denmark	
Sweden	
New Zealand	
Norway	
Austria	
Colombia	
Belgium	
Greece	
Portugal	
Chile	
Egypt	
Hungary	
Pakistan	
Finland	
Switzerland	
Bulgaria	

When Table 7 is examined the countries included in Cluster 1 for the year 2021 consist of a diverse group with various energy consumption profiles and economic structures. These countries generally possess diverse energy resources and are taking significant steps to diversify their energy consumption. For example, some European countries (such as Germany and France) are known for their policies towards renewable energy and make substantial investments in this area. Additionally, countries like Canada are recognized for their natural resource-based energy sectors, while others like Spain and Portugal invest in renewable sources such as hydroelectric and solar energy. Countries like Türkiye, on the other hand, focus on energy supply security and sustainability. Economically, most of the countries included in Cluster 1 generally have medium to high-income levels and broad industrial bases. These countries exhibit diversity in industries, trade, tourism, and other sectors. This diversity shapes energy demand according to the need for different sources and leads to a variety of national energy policies. Countries in Cluster 1 encounter various challenges in their energy policies and transformation processes. Issues such as energy supply security, environmental sustainability, and balancing economic growth are at the forefront. Many of these countries adopt policies aimed at increasing energy efficiency, promoting renewable energy use, and reducing greenhouse gas emissions. Overall, the countries included in Cluster 1 are diverse in terms of energy consumption and economic structure, playing an important role in energy transformation processes. Their energy policies and practices prioritize sustainability and innovation in the energy sector, tailored to national priorities, resources, and international contexts.

The countries included in Cluster 2 for the year 2021 constitute a group of countries with vast geographical areas and diverse economic structures. These countries exhibit diversity in their energy consumption profiles and economic structures. For example, large economies like the United States and China have high energy demand and are generally dependent on various energy sources. The United States is one of the world's largest countries in terms of energy consumption and is known for its fossil fuel-based energy sectors, while China experiences increased energy demand due to rapid industrial growth. On the other hand, countries like Japan and Iran base their energy consumption profiles on specific sources, such as nuclear energy and oil. Russia possesses rich energy resources like natural gas and oil, whereas Brazil invests in renewable energy sources such as hydroelectric and biomass. Economically, countries included in Cluster 2 generally have medium to high income levels and diverse industrial sectors. For instance, countries like the United States and Japan have strong industries in advanced technology, automotive, healthcare, and finance. Countries like India and Brazil are notable for their rapidly growing economies, leading to an increase in energy demand proportional to this growth. Countries in Cluster 2 face various challenges in their energy policies and transformation processes, with issues such as energy supply security, environmental sustainability, and balancing economic growth at the forefront. Their energy policies are shaped by national priorities, resources, and international contexts, emphasizing sustainability and innovation in the energy sector.

The transition of countries like Iran, Netherlands, Mexico, and Luxembourg from Cluster 1 in 2000 to Cluster 2 in 2021 reflects the complexity of changes in energy consumption groupings. To explain the underlying reasons for these changes in more detail, various factors should be considered. Firstly, changes in energy policies and strategies can be influential. Altering a country's policies regarding its energy resources or increasing investment in renewable energy, for example, can affect energy consumption profiles. Additionally, changes in economic conditions and international relations can also play a role in these transitions. Economic growth or stagnation in a country can led to changes in industrial activities and, consequently, energy demand. Furthermore, alterations in international energy trade and diplomatic relations can impact energy policies. Understanding these changes can assist in better managing energy consumption groupings and planning energy transition processes more effectively. The transitions of countries like Canada, Germany, Italy, Spain, and the United Kingdom from Cluster 2 in 2000 to Cluster 1 in 2021 can be explained by the interaction of various theoretical and practical factors. To understand the underlying reasons for these transitions, various factors should be considered. Firstly, changes in the energy policies and strategies of these countries can be influential. Measures such as increasing incentives for renewable energy or adopting policies to reduce carbon emissions can lead to changes in energy consumption profiles. Additionally, economic factors can also play a role in these transitions. Periods of economic growth or stagnation can affect industrial activities and, consequently, the trajectory of energy demand. Technological advancements also play a significant role. Technological progress in these countries can increase energy efficiency and promote the use of renewable energy sources. International relations and policies can also be influential in these transitions. Changes in global trade relations or international agreements can affect energy trade and subsequently influence the energy consumption profiles of these countries. Finally, environmental and social factors also play a role in these transitions. Society's environmental awareness and social expectations have a significant impact on shaping energy policies. By considering these factors together, a better understanding of the changes in energy consumption groupings of countries like Canada, Germany, Italy, Spain, and the United Kingdom can be achieved. This can help in more effectively planning and implementing future energy policies.

5. CONCLUSION

The clustering analysis revealed differences among countries included in the clusters formed in the years 2000 and 2021. In this context, the transition of countries such as Iran, the Netherlands, Mexico, and Luxembourg from Cluster 1 in 2000 to Cluster 2 in 2021 reflects the complexity of changes in energy consumption groupings. The underlying reasons for these changes encompass factors such as alterations in energy policies, economic conditions, international relations, and technological advancements. Similarly, the transitions of countries like Canada, Germany, Italy, Spain, and the United Kingdom from Cluster 2 in 2000 to Cluster 1 in 2021 can be attributed to the interaction of various factors. These may include changes in energy policies, economic growth or stagnation, technological progress, shifts in international trade relations, and environmental considerations. Understanding these changes can facilitate more effective planning and implementation of future energy policies.

The analyses conducted and the results obtained clearly demonstrate the complexity of changes in energy consumption groupings and the diversity of underlying reasons for these changes. For future studies, several recommendations can be made: In future research, conducting more detailed analyses of factors such as the energy policies, economic conditions, technological infrastructures, and international relations of the countries in question may prove beneficial. These analyses can help us better understand the unique factors behind the changes in energy consumption groupings for each country. Various scenario analyses can be conducted to understand how changes in energy consumption groupings may unfold in the future. For instance, scenarios can be developed to explore the potential impacts of different energy policies and technological developments. Analyses focusing on specific sectors can be conducted to better understand changes in energy consumption groupings. For example, studies can be carried out focusing on energy consumption and transformation in industrial, residential, or transportation sectors. Future studies can focus on evaluating the effectiveness of specific energy policies and incentive measures. These evaluations can help us understand how certain policies and incentive measures impact changes in energy consumption groupings. These recommendations can contribute to a deeper understanding of changes in energy consumption groupings and aid in more effectively planning future energy policies.

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