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Differences in the Structure of Household Electricity Prices in EU Countries

Aleksandra Matuszewska-Janica [1], Dorota Żebrowska-Suchodolska [1,*], Mariola E. Zalewska [2], Urszula Ala-Karvia [3] and Marta Hozer-Koćmiel [4]

[1] Institute of Economics and Finance, Warsaw University of Life Sciences—SGGW, Nowoursynowska 166, 02-787 Warsaw, Poland; aleksandra_matuszewska@sggw.edu.pl
[2] Faculty of Management, University of Warsaw, Szturmowa 1/3, 02-678 Warsaw, Poland; me.zalewska@uw.edu.pl
[3] Ruralia Institute, University of Helsinki, Kampusranta 9 C, 60320 Seinäjoki, Finland; urszula.ala-karvia@helsinki.fi
[4] Institute of Economics and Finance, University of Szczecin, Mickiewicza 64, 71-101 Szczecin, Poland; marta.hozer-kocmiel@usz.edu.pl
* Correspondence: dorota_zebrowska_suchodolska@sggw.edu.pl

Abstract: Private households are an important group of energy consumers. Based on Eurostat data, their energy consumption constituted 30% of the final consumption of energy use across the European Union in 2021. The cost of energy is one of the main components of household budgets; thus, the prices provided by energy carriers have a significant impact on energy consumption. The price offered to the final consumer consists of three components: the price of energy and its supply, network costs, and taxes and levies. The values of the three components, however, depend on several factors, among which the structure of the energy markets and energy policies in individual EU countries play a key role. This work aimed to analyze and assess the structure of electricity prices offered to households across EU countries in the years 2019–2021. The differences and similarities between the pricing policies of selected products in the EU and their impacts on households' purchasing capacity were captured and a non-pattern classification method (k-means) was applied as a research tool. The results indicated that the heterogeneity of the electricity price structure increased significantly over the period analyzed. This may be a consequence of the use of strongly differentiated tools to mitigate electricity price increases and the steps being taken towards low-carbon economies.

Keywords: electricity prices; structure of electricity prices; households; EU countries; classification; k-means; Sustainable Development Goals (SDG)

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1. Introduction

A well-developed energy system is a key enabler of socioeconomic development, which is achieved by ensuring that everyone has access to affordable, reliable, sustainable, and modern energy. Therefore, the creation of energy policies is one of the most important activities undertaken by state authorities.

Between 2010 and 2020, the global electricity access rate increased significantly from 83% to 91%. The number of people without access to the network fell from 1.2 billion in 2010 to 733 million in 2020. In 2020, 76% of the world's population without access to electricity lived in 20 countries, 15 of which were in sub-Saharan Africa [1]. On the other hand, in the European Union (EU) countries, the rate of access to electricity reached a maximum value of 100% in 2020. This underlines the fact that European countries put emphasis on different aspects of the energy system and related problems than in many other parts of the world.

According to Eurostat data, in 2021, the share of households (residential sector) in final energy consumption was 27% [2,3]. Compared to 2020, this figure decreased by about

0.4 percentage points (pp); however, compared to 2019 it increased by almost 2 pp. This increase in household energy consumption in 2020 was directly related to the lockdowns caused by the COVID-19 pandemic [4–6]). In addition, it is worth noting that in 2021, the demand for energy carriers across the economy increased significantly compared to 2020, which can be explained by economic recovery after the lockdown period [7]. The increase in both energy consumption and price has contributed significantly to the increase in household expenditures in this area. This may result in an increase in the number of households at risk of energy poverty. The problem has recently intensified due to the war in Ukraine. European countries have taken numerous measures to reduce final energy prices, e.g., by reducing energy pricing (see [8]). Energy poverty constitutes a major challenge for the EU [9]. For this reason, many actions are being taken in this area, not only at the EU level but importantly at the national level as well.

Due to the different sources and costs of generating, transmitting, distributing, and selling electricity, electricity prices vary between the 27 EU member states. Within 3 years (2019–2021), electricity prices for households increased by almost 7% on average in all 27 EU countries. The largest increases were recorded in Estonia (24.5%) and Poland (20.6%). However, prices have also decreased. An exceptional example is the Netherlands, where the price per kWh decreased by more than 35% during this period.

The EU pursues an active energy policy using a comprehensive and integrated approach to energy and climate policy, consistent with the Sustainable Development Goals [10]. The European Commission has adopted six priorities for 2019–2024, including the European Green Deal, an action plan to transform the EU into a modern, resource-efficient, and competitive economy by tackling energy poverty, reducing external energy dependency, and reducing emissions. These actions will have a significant impact on the price of energy. In some cases, they will lower it; in others, they will increase it (e.g., in countries where fossil fuels are used to a greater extent, such as Poland, or in countries where the use of non-emission sources is largely subsidized, such as Germany). It follows that the price of energy (in particular electricity) is not only a result of supply and demand but is influenced by many factors, including those related to the energy policy.

The above description is the motivation for this study, in which we will present the classification of the 27 EU countries by the structure of household electricity prices from 2019 to 2021.The final price of electricity includes three components: (1) energy and supply cost (*ES*); (2) network cost (*EN*); and (3) taxes, fees, levies, and charges included in the electricity price (*ET*). Using this classification, we will indicate the impact of individual components on the final price offered to households in individual EU countries and point out the similarities and differences between these countries in terms of the structure of electricity prices. The analysis will verify the assumption that the heterogeneity of EU countries has increased in the last two years due to the structure of electricity prices, mainly as a result of measures related to the containment of the COVID-19 pandemic and the EU's efforts to work towards low-emission economies. These results are important in the context of energy poverty, the liberalization of markets, and sustainable development.

2. Sustainability Indicators

At the UN General Assembly in 2015, 17 Sustainable Development Goals (SDGs) were adopted, providing new perspectives and frameworks for member states to face the challenges associated with global development. SDG #7 concerns energy, where access to affordable energy is indicated as the most important feature in its description. Over the years, access to electricity has changed [1].

When they signed Agenda 21, the leaders of the 182 countries at the Earth Summit in Rio de Janeiro in June 1992 committed themselves to measuring the progress of sustainable development using quantitative and reliable data. Since then, many systems of sustainable development indicators have been developed, both at the levels of territorial division from global to local and broken down by economic sectors such as construction, agriculture, transport, tourism, etc. In this article, we focus on the household energy price index but show it in a broad context [11]. Three categories of indicators can be found in the literature: single indicators; a group or dashboard of disaggregated individual indicators; and compound indices. The review of existing sustainable energy development indicators is carried out by the International Atomic Energy Agency. The IAEA has developed a set of energy indicators for sustainable development, published as Energy Indicators for Sustainable Development: Guidelines and Methodologies. The collection consists of 30 indicators divided into three dimensions: social (SOC, 4 measures), economic (ECO, 16 measures), and environmental (ENV, 10 measures). Some of these indicators correspond to private households. For example, three of the four indicators in the social dimension focus on households, including SOC1 (the share of households (or population) without electricity or commercial energy or heavily dependent on non-commercial energy), SOC2 (the share of household income spent on fuel and electricity), and SOC3 (household energy use for each income group and corresponding fuel mix). Two of the indicators in the economic dimension also address households directly, including ECO9, (household energy intensities) and ECO14 (end-use energy prices by fuel and by sector). The description of ECO9 specifies that energy prices for households may be subject to regulation. These regulations aim to consider environmental and social costs, manage supply and demand, and encourage the development of alternative renewable energy options. The main aim is to use energy efficiently through price mechanisms, which help to overcome inefficiencies [12]. Another set of eight sustainable energy development indicators was proposed by Organizacion Latinoamericana de Energia (OLADE), Economic Commission for Latin America and Caribbean (ECLAC), and Deutsche Gesellscaft fuer Techische Zusammennarbeit (GTZ) to demonstrate energy sustainability, including energy self-sufficiency, resilience in the face of external change, energy efficiency, electricity coverage, the coverage of basic energy needs, the relative purity of energy consumption, the use of renewable energy sources, and the use of a range of fossil resources and firewood [13]. The Energy Development Index developed by the International Energy Agency (IEA) focuses on the transition to the use of modern fuels in a country or region [14]. Selected energy-related aspects can also be measured using the Multidimensional Energy Poverty Index (MEPI) [15]. The Household Energy Price Index survey conducted in 33 countries for the 2022 year showed that depending on their place of residence, the price for the end user varied considerably (5.05 euro cents/kWh) [16].

3. Literature Review

Electricity is an important determinant of socioeconomic development [17]. In the long term, it has a positive impact on economic development as well as the development of the private sector [18] and public sector, including education and health care. These relationships are often multidimensional [19] and multidirectional [20].

Household surveys on electricity focus mainly on access to electricity or a lack of it. Access to energy, on the other hand, is closely related to its consumption and can be considered both at the micro and macro level [21]. Per capita electricity consumption is also one of the indicators of energy and development provided by the World Bank [22]. There are many determinants, often grouped as social, economic, and psychological, of energy consumption for households. The main economic factor is household income [23–26], as energy consumption is considered a determinant of living standards [27,28]. Another important aspect related to energy consumption is location, which should be considered on many levels. Energy consumption is therefore considered separately for developed and developing countries [29–31]. At the lower level, it is the urban–rural divide [32–35]. However, differences in energy consumption at the city level also have to be reported [24]. At the micro level, energy consumption can be considered, for example, per number of people in the household [36], where single-person households are the most burdened group [37]. Another important economic factor determining energy consumption is price, which shows a negative correlation [38]. Social factors include the awareness of residents, which influences the appropriate choice of heating devices [39], and gender [40]. Among psychological factors, beliefs and attitudes, intentions and motives, cost–benefit appraisals, and social and personal norms stand out [41].

The second important issue raised for households is the lack of access to energy. This also raises the issue of energy poverty. The definition of energy poverty varies. However, all definitions are associated with the demarcated possibilities of satisfying basic needs [42]. This is a result of a lack of sufficient choice in access to energy or a general lack of access to energy [43]. Due to this division, indicators examining energy poverty are separated into those that focus on the assessment of access to energy [44] or on the lack thereof [11,45]). In 2019, 759 million people worldwide did not have access to electricity, accounting for 10% of the population [46]. Ensuring 100% access to energy by 2030, which is one of the Sustainable Development Goals, may become impossible [47]. In addition, the effects of the COVID-19 pandemic and the war in Ukraine have become limiting factors in the achievement of this goal.

The literature describes numerous examples of energy injustices and inequalities that directly or indirectly affect households. The occurrence of energy injustice can cause an unequal distribution of risks and benefits in different dimensions, including countries, social groups, and individuals. Energy injustice and inequality can be associated with all forms and stages of energy harvesting and the conversion from harvesting to final use [48]. An example of energy injustice and imbalance is the energy burden that occurs when some households pay a disproportionately high percentage of their income to cover the costs of energy services. Another example is energy poverty, where households are unable to afford the energy needed to sustain everyday life [49]. Energy poverty can also lead to further injustices and inequalities that can have negative health effects. The high price of electricity boosts the use of substitutes, e.g., contaminated energy sources that may increase the incidence of cardiovascular disease, respiratory problems, or allergies. As reported in the study by Sovacool carried out on four European low-carbon transition systems—nuclear power in France, smart measurement system in the UK, electric vehicles in Norway, and photovoltaic panels in Germany—numerous inequalities and injustices have occurred spread across three spatial scales, starting with the micro-scale, which includes direct local impacts on family life, community health, and the environment; through the meso-scale, encompassing national issues including rising electricity prices and limited or lack of access to modern forms of energy or low-carbon technologies; to the macro global scale, which includes mineral and metal mining and the circulation of waste streams [50].

Electricity is the second largest source of final energy consumption for households [51]. It is mostly used for lighting and the functioning of household appliances [52], in addition to providing a source of heating and cooling [6]. Renewable energy issues are widely discussed in the literature in many contexts, including energy justice and energy poverty. They were also the subject of a previous study by the authors of this work [53].

The price of energy itself has been the subject of many analyses. It is partly influenced by the wholesale market price as well as distribution fees [54]. The wholesale market price is not entirely passed on to the consumer due to different types of surcharges at the national level. For this reason, it is not a completely liberalized market. A description of the process of the liberalization of the electricity market in the EU can be found in [55]. The introduction of three directives by the EU in this area has not made major changes in this respect, e.g., it has not reduced concentration or decreased energy prices. The situation may continue until a suitable competitive market is created [56]. However, if the environmental impact is reduced, electricity prices will rise, and this will result in a decrease in competitiveness [57].

The individual components of energy prices are an important issue. The price components of the European Commission, such as network costs, energy costs, taxes, and retail costs, can be found in [58]. Individual price components and the final price are most often considered in the context of their forecasting or effectiveness. Forecasting short-term energy prices is targeted in [59–61], among others. The optimal planning of energy consumption is considered, for example, in [62], while the search for a higher degree of distribution tariff efficiency is pursued in [63].

An analysis of countries in terms of energy components for households is provided by the European Commission in their report on energy prices and costs [64]. The following components are listed here: electricity price, VAT, and other taxes and charges. Studies using these components are described in [65,66]. The authors of [65] studied the impact of electricity prices on energy intensity in Europe, while [66] presents the share of VAT and other components in the price of electricity for households. For the EU27 countries in the period of 2011–2020, the k-means method was used to divide the countries into four groups based on the price of electricity for households in euro cents per kWh. The highest average electricity price was found in Germany and Denmark, which constituted cluster II. The average energy price for this cluster was almost 68% higher than the average of all EU countries. The study described in [65] was conducted in euro cents per kWh, not in PPS; thus, its results are not fully reliable. In general, the literature does not take into account individual elements of the price, but rather the percentage shares of the individual values of electricity costs. This paper fills that research gap. Fluctuating electricity prices and components are important issues in the context of the classification of the EU27 countries in terms of household electricity prices. Thus, countries grouped in the same clusters will show a similar structure within these prices. The analysis of results over the years will additionally allow us to provide an answer about the stability of individual clusters and the impact of the components on these clusters.

4. Data

The data employed in this analysis were taken from publicly available Eurostat databases [67]. According to Eurostat, the price of electricity offered to businesses and households is the sum of three components (see Formula (1)). Energy and supply cost (*ES*), network cost (*EN*), and taxes, fees, levies, and charges (*ET*) are included in the electricity price (*EP*) as follows:

$$EP_i^t = ES_i^t + EN_i^t + ET_i^t \quad (1)$$

where ES_i^t represents the energy and supply cost in the ith country and year t (in EUR or PPS); EN_i^t is the network cost in the ith country and year t (in EUR or PPS); and ET_i^t denotes the taxes, fees, levies, and charges included in the electricity price in the ith country and year t (in EUR or PPS). Eurostat provides electricity prices (*EP*) and the values of these components (*ES*, *EN*, and *ET*) both in EUR and in the purchasing power standard (PPS), which is an artificial currency unit. The PPS is used by Eurostat to compare the currencies of different countries via a 'basket of goods and services' approach, where one PPS can buy the same amount of goods and services in each country [68].

The energy and supply component (*ES*) includes generation, aggregation, balancing energy, supplied energy costs, customer service, after-sales management, and other supply costs [69]. The network cost component (*EN*) refers to transmission and distribution tariffs, transmission and distribution losses, network costs, after-sale service costs, system service costs, and meter rental and metering costs [69]. The tax component (*ET*) is composed of six different fee categories [69]: (1) value-added taxes (VAT); (2) renewable taxes (taxes, fees, levies, or charges relating to the promotion of renewable energy sources, energy efficiency, and combined heat and power (CHP) generation); (3) capacity taxes (taxes, fees, levies, or charges relating to capacity payments, energy security, and generation adequacy; taxes on coal industry restructuring; taxes on electricity distribution; and stranded costs and levies on financing energy regulatory authorities or market and system operators); (4) environmental taxes (taxes, fees, levies, or charges relating to air quality and other environmental factors and taxes on the emission of CO_2 or other greenhouse gases, including excise duties); (5) nuclear taxes (taxes, fees, levies, or charges relating to the nuclear sector, including nuclear decommissioning and inspections and fees for nuclear installations); and (6) all other taxes (taxes, fees, levies, or charges not covered by any of the previous five categories, including support for district heating, local or regional fiscal charges, island compensation, concession fees relating to licenses, and fees for the occupation of land and public or private property by networks or other devices).

In the analysis presented here, we consider three variables representing the percentage shares of the individual values of the energy and supply cost (*ET*), network cost (*EN*), and taxes, fees, levies, and charges (*ET*) in the average price offered to households, EP_i^t (Formulas (2)–(4)). All these shares add up to 100 (Formula (5)).

$$ESs_i^t = \frac{ES_i^t}{EP_i^t} \cdot 100 \quad (2)$$

$$ENs_i^t = \frac{EN_i^t}{EP_i^t} \cdot 100 \quad (3)$$

$$ETs_i^t = \frac{ET_i^t}{EP_i^t} \cdot 100 \quad (4)$$

$$ESs_i^t + ENs_i^t + ETs_i^t = 100 \quad (5)$$

It is worth noting that Eurostat provides the unit prices of electricity and the costs of its individual components in the consumption ranges (engbands, see [69]). Data averaged for the whole country (without division into consumption ranges) are available from 2017 onwards. Due to the lack of data from earlier periods, we included the years t = 2019, 2020, and 2021 in our analysis.

This empirical analysis includes 26 EU countries (according to the 2020 composition). The Netherlands was omitted due to the fact that in 2020 and 2021, the value of the taxes, fees, levies, and charges component was less than zero ($ET_{NL}^{2020} < 0$ and $ET_{NL}^{2021} < 0$). We treated this country as an outlier observation. The Dutch policy on electricity prices offered to households is presented later in this article.

5. Methodology

The analysis is divided into two parts. First, we demonstrate the dynamics of the average prices offered to households in the European Union countries between 2019 and 2021. Second, the countries are classified by their electricity price structure. We applied *k*-means as a research tool to cluster the EU countries. This algorithm was originally introduced by McQueen (1967), and its description can be found in multiple papers, such as [70–72], among others. The procedure of applying the *k*-means algorithm involves several steps, including (see [73]) (1) the selection of variables and objects, (2) variable normalization, (3) the selection of a clustering method and distance measure, and (4) the selection of the number of clusters.

We included three normalization methods in the analysis: standardization, positional standardization, and unitization with zero minimum [74]. Several variants were also considered when calculating the distance between objects, including the Manhattan distance and Euclidean distance, which are among the most commonly used methods, and the generalized distance measure (GDM, see [75,76]). The final step involved the selection of the number of classes, *k*. We considered divisions with different numbers of clusters (*k*); however, due to the small number of objects (26 countries), we limited the scope of these considerations to k = 2, 3,. . ., 12. The silhouette index (SI, [77] pp. 83–88) was used to select the best division. A description of this index can also be found in [78,79]. The highest value of the SI indicates the best number of clusters. The literature suggests that acceptable divisions are characterized by an SI of at least 0.5 (the structure of the clustering is then considered reasonable; see [77,79,80].

Classification was conducted by applying the procedures implemented in R packages (version R-4.2.2 in RStudio 2023.03.2+454). The following libraries were used for the analysis: `ClusterSim` was used to conduct the main analysis [81], `RobustHD` was used to generate a silhouette width [82] and `factoextra was` used for data visualization [83].

The results presented here were obtained by adopting unitzsation with zero minimum as the method for normalizing variables. Distances between objects were calculated using the Generalized Distance Measure. The `kmeans()` function with the following parameters: `iter.max=100`, `nstart=10`, `algorithm='Ma-cQueen'`, was used for classification.

6. Changes in the Prices of Electricity Offered to Households in EU Countries

Table 1 presents the average electricity prices EP_i^t (see Formula (1), measured in PPS/kWh) between 2019 and 2021 in European Union countries and their changes. These are the nationally averaged prices (so-called single national electricity prices) reported in the database [67]. This database includes information from 2017 onwards, with difficult-to-fill data gaps for single national electricity prices in 2017 and 2018. As mentioned earlier, information on electricity prices offered to households is usually reported for consumption bands (see [69]). In contrast, single national electricity prices are calculated as weighted averages for consumer bands [69].

Table 1. Average electricity prices in EU countries (EP_i^t in PPS/kWh) in 2019–2021.

Region/Country	Price (PPS/kWh)			Change (%)		
(*i*)	2019	2020	2021	2020/2019	2021/2020	2021/2019
EU27	0.2180	0.2194	0.2330	0.6	6.2	6.9
Belgium	0.2507	0.2439	0.2564	−2.7	5.1	2.3
Bulgaria	0.1835	0.1841	0.1948	0.3	5.8	6.2
Czech Republic	0.2327	0.2474	0.2363	6.3	−4.5	1.5
Denmark	0.1994	0.1844	0.1948	−7.5	5.6	−2.3
Germany	0.2706	0.2857	0.2956	5.6	3.5	9.2
Estonia	0.1655	0.1534	0.2061	−7.3	34.4	24.5
Ireland	0.1974	0.1998	0.2248	1.2	12.5	13.9
Greece	0.2011	0.2082	0.2321	3.5	11.5	15.4
Spain	0.2758	0.2600	0.3074	−5.7	18.2	11.5
France	0.1635	0.1735	0.1772	6.1	2.1	8.4
Croatia	0.2044	0.2051	0.2038	0.3	−0.6	−0.3
Italy	0.2597	0.2504	0.2614	−3.6	4.4	0.7
Cyprus	0.2499	0.2101	0.2335	−15.9	11.1	−6.6
Latvia	0.2286	0.2219	0.2387	−2.9	7.6	4.4
Lithuania	0.1856	0.2026	0.2077	9.2	2.5	11.9
Luxembourg	0.1367	0.1517	0.1469	11.0	−3.2	7.5
Hungary	0.1694	0.1684	0.1626	−0.6	−3.4	−4.0
Malta	0.1848	0.1797	0.1775	−2.8	−1.2	−4.0
The Netherlands *	0.1742	0.1132	0.1124	−35.0	−0.7	−35.5
Austria	0.1764	0.1855	0.1937	5.2	4.4	9.8
Poland	0.2314	0.2630	0.2790	13.7	6.1	20.6
Portugal	0.2726	0.2676	0.2635	−1.8	−1.5	−3.3
Romania	0.2616	0.2800	0.3036	7.0	8.4	16.1
Slovenia	0.1917	0.1827	0.1925	−4.7	5.4	0.4
Slovakia	0.2033	0.2184	0.2047	7.4	−6.3	0.7
Finland	0.1237	0.1216	0.1242	−1.7	2.1	0.4
Sweden	0.1368	0.1191	0.1536	−12.9	29.0	12.3

Source: Own elaboration based on [67]. * The Netherlands is included in this table for comparative purposes. In the classification of EU countries, this country was not considered due to the negative values of the *ET* component.

In 2019, the highest prices (in PPS) were recorded in Spain (0.2758), Portugal (0.2726), Germany (0.2706), Romania (0.2616), Italy (0.2597), and Belgium (0.2507). In contrast, the lowest average energy prices were observed in Finland (0.1237), Luxembourg (0.1367), and Sweden (0.1368). In 2021, households paid the most per unit of electricity in Spain (0.3074), Romania (0.3036), Germany (0.2956), and Poland (0.279). The lowest prices were noted in the Netherlands (0.1124), Finland (0.1242), Luxembourg (0.1469), and Sweden (0.1536). In the EU27 area, the average price of electricity offered to households increased by 6.9% in 2021 compared to 2019. The countries where prices increased the most during the period under review were Estonia (by 24.5%), Poland (by 20.6%), and Romania (by 16.1%). Prices fell in seven countries, decreasing the most in the Netherlands, by 35.5%. However, this value can be treated as an outlier. In the remaining six countries, these declines ranged between 6.6% and 0.3%.

Looking at year-on-year change, price decreases were recorded in 14 countries in the 2020/2019 season, but only 8 in the 2021/2020 season. It is also worth noting that in the 2020/2019 season, prices fell on average by 5.4% (in countries with negative change, excluding the Netherlands which is an outlier), while in the 2021/2020 season, the average decrease was 2.7%. In contrast, in countries with price increases, the average increase was higher in the 2021/2020 season (9.5%) than in the 2020/2019 season (5.9%). This situation is a result of the fact that, in general, the large-scale lockdowns in 2020 resulted in slower economic development, which had a significant impact on reducing energy consumption, also leading to higher volatility in the prices of raw energy materials and the energy produced. It is also not insignificant that in many countries, it is the governments that have influenced energy prices in an attempt to limit the negative effects of economic downturns and reduce energy poverty during the pandemic [84].

The values of the individual components (in PPS) are presented in Figures 1–3. It is worth noting that in Spain, Portugal, and Germany, the component with the largest share in the price of energy was taxes and fees (ET_i^t), which was at least 45% and even over 52% in Germany. In Romania and Italy, on the other hand, the energy component (ES_i^t) had the largest share ES_i^t, with over 40%. The countries with the lowest price of electricity offered to households were Finland (0.1237), Luxembourg (0.1367), and Sweden (0.1368). These are the only countries where the price per kWh was below 0.05 PPS. While all price components (ES_i^t, EN_i^t, ET_i^t) had a similar weight in Finland, the tax component accounted for the largest share of the price in Sweden (over 40%) and network costs EN_i^t made up the largest share in Luxembourg (also over 40%).

The Netherlands has had an active policy on environmental taxes for years. In response to rising energy prices—and inflation—an aid package has been introduced to mitigate the impact on people with low and middle incomes. Since inflation is expected to rise to 5.2%, driven by rising energy prices and purchasing power falling by an average of 2.7%, the government has raised the one-off energy allowance (Dutch energietoeslag) for people with incomes similar to social assistance benefits (EUR 800). The value-added tax (VAT) rate on energy has also been reduced from 21% to 9% [85]. As reported by CBS Centraal Bureau voor de Statistiek, [86]), "the largest discrepancy between the energy bills of January 2019 and January 2020 is found in the tax credit received by each household".

In all other countries, increases ranged from 0.4% to 24.5%. The two largest increases were recorded in Estonia (by 24.5%, from 0.1655 PPS to 0.2061 PPS) and in Poland (by 20.6%, from 0.2314 PPS to 0.2790 PPS). Poland joined the list of countries with the highest energy price per kWh (above 0.25 PPS), while in Spain and Romania, the price increased to above 0.3 PPS. In these two countries, the largest share (43.9% and 45.8%, respectively) corresponded to the component related to energy production (ES).

Changes in the costs of individual components are presented in Figures 1–3. The change throughout the period (2021/2019) is represented by a shaded area. The annual changes are presented as lines with markers, where red indicates changes in the 2021/2020 season and blue denotes changes in the 2020/2019 season.

Across the EU, the value of the ES component increased by 21%. At the same time, when we looked at annual changes, this value decreased by 2.6% in 2020; however, in the next year, it increased by 24.3%. The biggest changes in the ES component in the period of 2019–2021 were recorded in Spain (an increase of 76.8%) and Estonia (an increase of 56.5%). In the case of Estonia, this translated to a significant increase in the price of total energy (by 24.5%). In Spain, on the other hand, the significant increase in the value of the ES component was largely offset by the decrease in the value of the ET component (the component related to taxes and other fees added to the final price). In seven countries, the value of this component increased by at least 20% (Denmark, Germany, Greece, Sweden, Czechia, Romania, and Latvia). In contrast, in six countries, its value decreased (Belgium, Croatia, Ireland, Malta, Cyprus, and Hungary). The largest decreases occurred in Finland (by 14.8%) and Sweden (by 15.7%). It is worth adding here that the annual change in 2020 was negative in 15 of 27 countries.

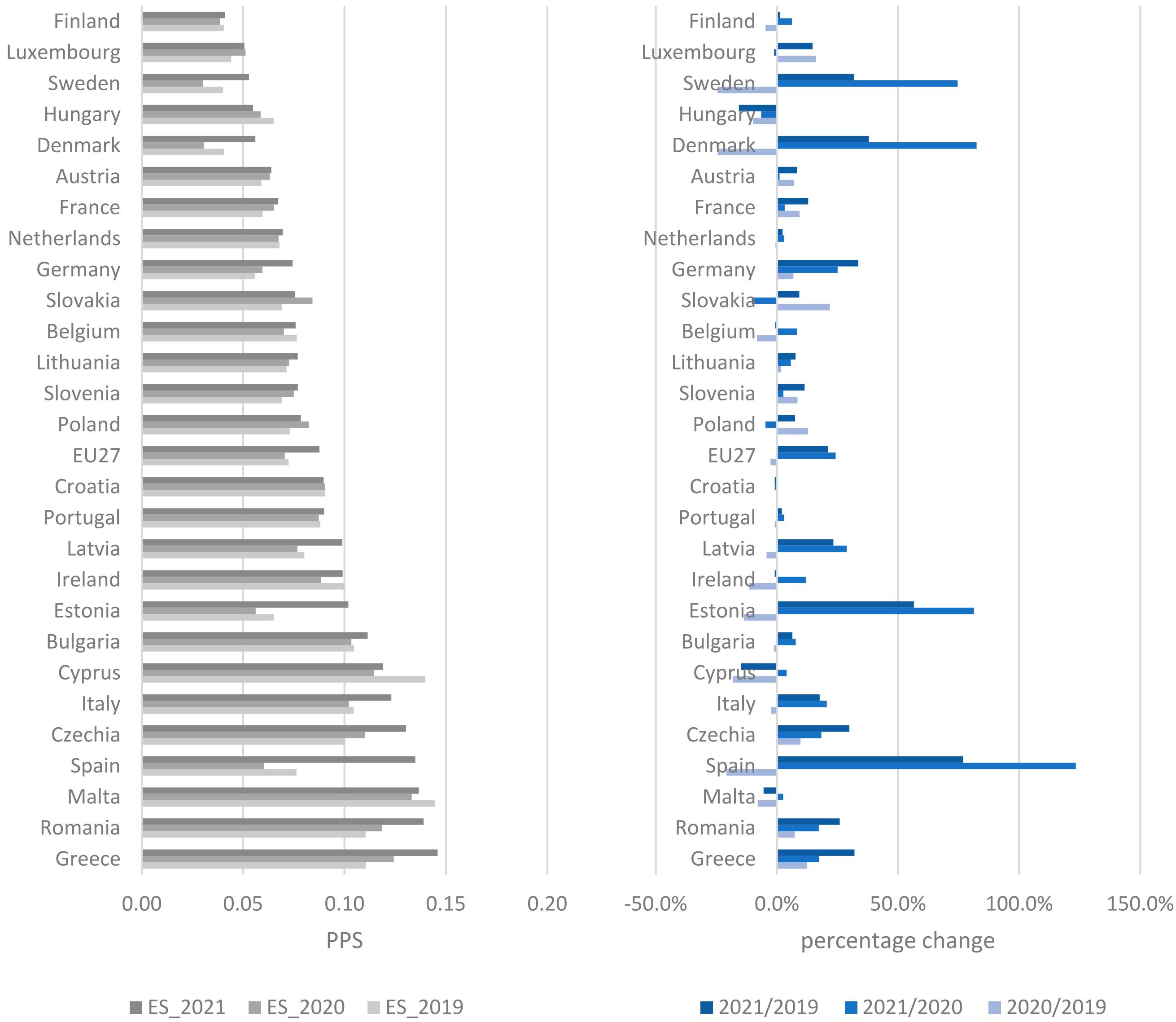

Figure 1. Values of the energy supply component (ES_i^t in PPS) in 2019, 2020, and 2021 and changes in the values of this component in 2021/2019, 2021/2020, and 2020/2019 in EU countries. Source: own elaboration based on [67].

Across the EU, the value of the *ES* component increased the most during the analyzed period (by 21%). Network costs (*EN*) increased by 5.6% during this period, while the value of the *ET* component decreased by 4%. Looking at the variability in these components between countries, the largest was recorded for *ET* (coefficient of variation $CV_{s(ET)}^{2021} = 52.9\%$, increased compared to 2019 by 5 pp), while the smallest was observed for *EN* ($CV_{s(EN)}^{2021} = 26.6\%$, higher by 2.5pp compared to 2019). The coefficient of variation (CV) is defined as the ratio of the standard deviation over the mean [87]. In the case of the variation coefficient for ES, it was 33.9% in 2021, lower than in 2019 by 1.1 pp. This primarily indicates increasing variability in the part of the electricity price related to taxes and other charges, which may have the highest impact on the heterogeneity of EU countries with respect to household energy prices.

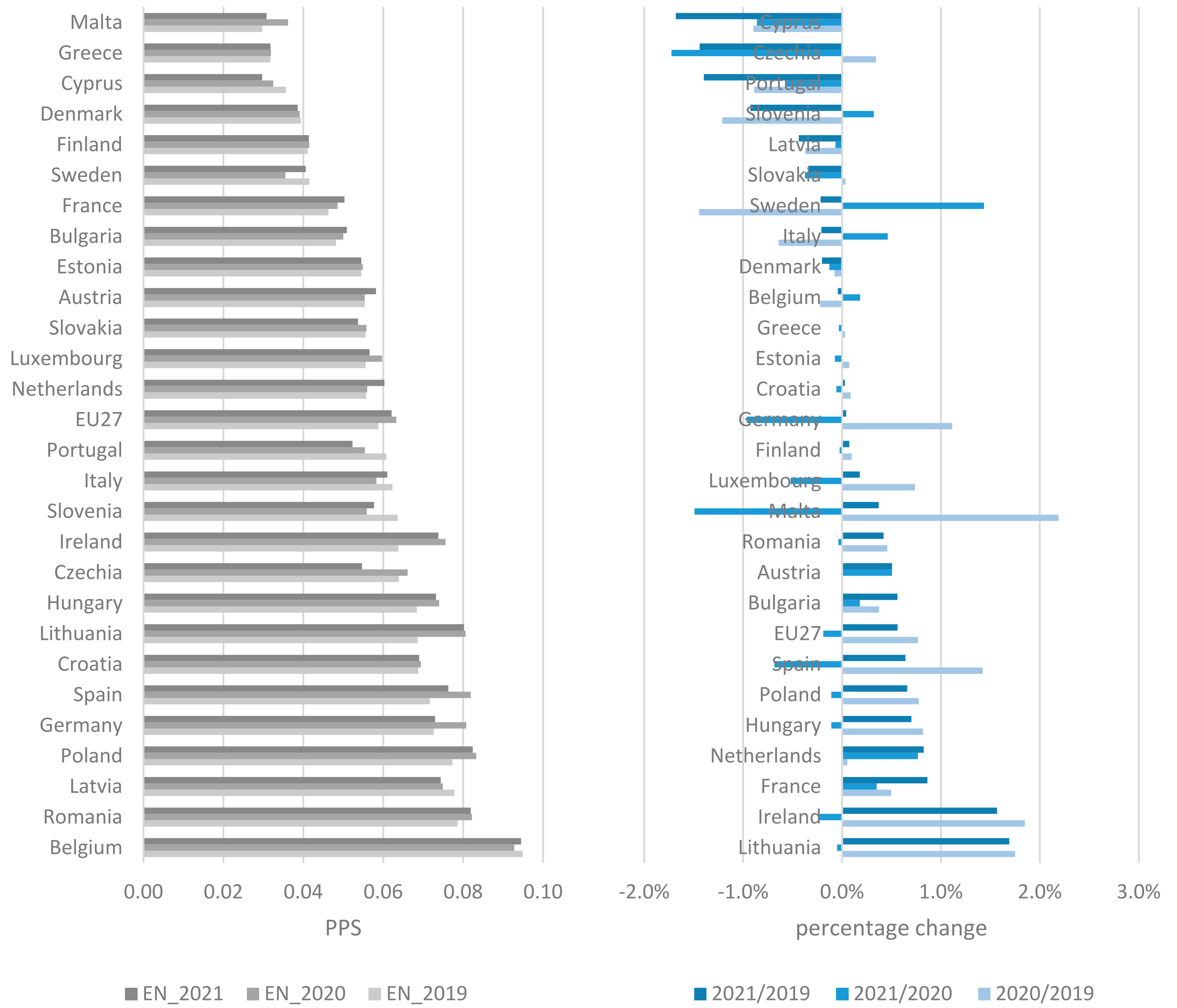

Figure 2. Values of the network costs component (EN_i^t in PPS) in 2019, 2020, and 2021 and changes in the value of network costs in 2021/2019, 2021/2020, and 2020/2019 in EU countries. Source: own elaboration based on [67].

Results of Grouping EU Countries according to Electricity Price Structure

Tables 2–4 present selected results from the cluster classification of the EU countries (average values of the analyzed characteristics in the individual clusters). In the tables, we used the following indications: ESs_k^t—mean share of the energy and supply cost included in the final energy price in the kth cluster and year t; ENs_k^t—mean share of the network costs included in the final energy price in the kth cluster and year t; ETs_k^t—mean share of the taxes, fees, levies, and charges included in the final energy price in the kth cluster and year t.

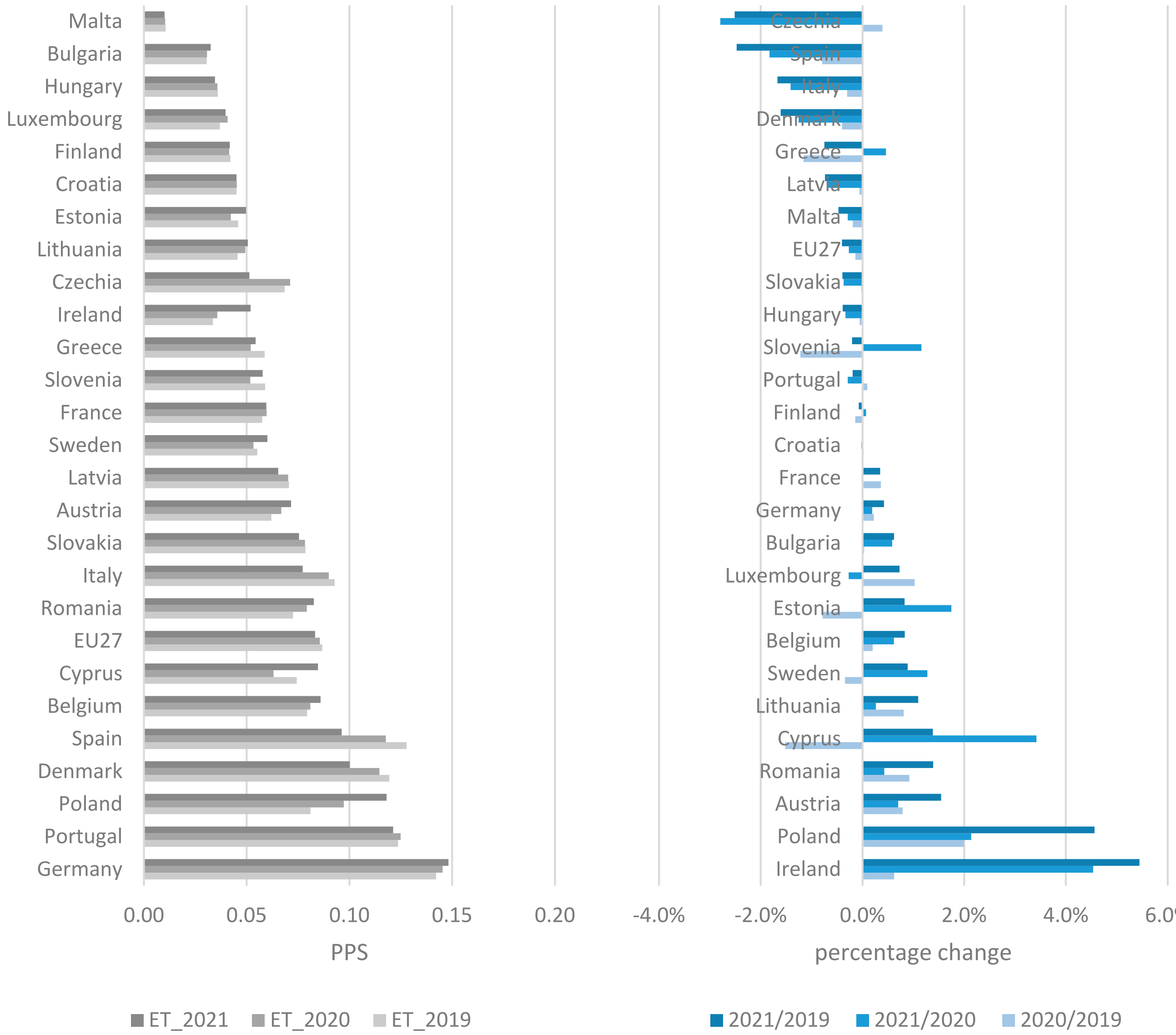

Figure 3. Values of the tax component (ET_i^t in PPS) in 2019, 2020, and 2021 and changes in the value of this component in 2021/2019, 2021/2020, and 2020/2019 in EU countries. Source: own elaboration based on [67].

Table 2. Selected results from the cluster analysis of EU countries for 2019 (average values of the variables in the clusters).

Cluster *k*	No. of Objects	Countries	ESs_k^{2019}	ENs_k^{2019}	ETs_k^{2019}
1^{2019}	4	Bulgaria, Greece, Cyprus, Malta	0.6155	0.1810	0.2035
2^{2019}	7	Denmark, Germany, Spain, Italy, Portugal, Slovakia, Sweden	0.2921	0.2522	0.4555
3^{2019}	15	Belgium, Czech Rep., Estonia, Ireland, France, Croatia, Latvia, Lithuania, Luxembourg, Hungary, Austria, Poland, Romania, Slovenia, Finland	0.3763	0.3372	0.2864

Source: own calculation using R package.

Figures 4–6 show the visualization of the obtained divisions. The silhouette index was used to select the best number of classes (SI values for each grouping are presented in Table A1 in Appendix A).

Table 3. Selected results from the cluster analysis of EU countries for 2020 (average values of the variables in the clusters).

Cluster *k*	No. of Objects	Countries	ESs_k^{2020}	ENs_k^{2020}	ETs_k^{2020}
1^{2020}	2	Greece, Cyprus	0.5710	0.1539	0.2750
2^{2020}	5	Belgium, Latvia, Austria, Poland, Finland	0.3210	0.3349	0.3441
3^{2020}	6	Czech Rep., France, Italy, Romania, Slovenia, Slovakia	0.4080	0.2725	0.3195
4^{2020}	5	Denmark, Germany, Spain, Portugal, Sweden	0.2375	0.2620	0.4995
5^{2020}	2	Bulgaria, Malta	0.6512	0.2365	0.1123
6^{2020}	6	Estonia, Ireland, Croatia, Lithuania, Luxembourg, Hungary	0.3825	0.3842	0.2333

Source: own calculation using R package.

Table 4. Selected results from the cluster analysis of EU countries for 2021 (average values of the variables in the clusters).

Cluster k	No. of Objects	Countries	ESs_k^{2021}	ENs_k^{2021}	ETs_k^{2021}
1^{2021}	1	Malta	0.7696	0.1735	0.0569
2^{2021}	2	Greece, Cyprus	0.5693	0.1321	0.2986
3^{2021}	3	Denmark, Germany, Portugal	0.2934	0.2145	0.4920
4^{2021}	2	Bulgaria, Czech Rep.	0.5616	0.2464	0.1920
5^{2021}	3	Lithuania, Luxembourg, Hungary	0.3506	0.4072	0.2422
6^{2021}	4	Ireland, Croatia, Latvia, Slovenia	0.4238	0.3196	0.2566
7^{2021}	5	France, Austria, Poland, Slovakia, Sweden	0.3409	0.2813	0.3779
8^{2021}	4	Estonia, Spain, Italy, Romania	0.4655	0.2539	0.2806
9^{2021}	2	Belgium, Finland	0.3131	0.3509	0.3360

Source: own calculation using R package.

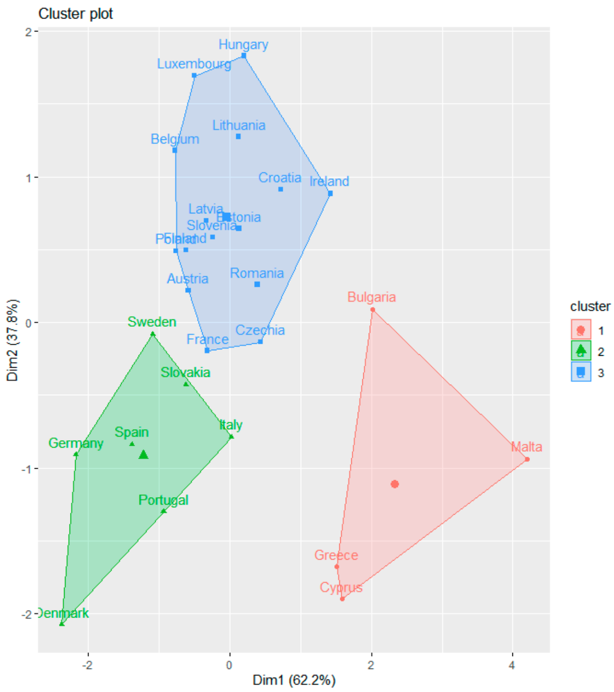

Figure 4. Visualization of EU states clustering (data for 2019). Note: Dim1 and Dim2 are artificial variables obtained after applying principal component analysis (PCA). PCA is a statistical procedure used for dimensionality reduction to help visualize multidimensional data. Dim1 and Dim2 represent the two most important principal components, which are combinations of the original variables in the dataset (and are ordered in decreasing order of importance, see [87]). Source: own elaboration using R package.

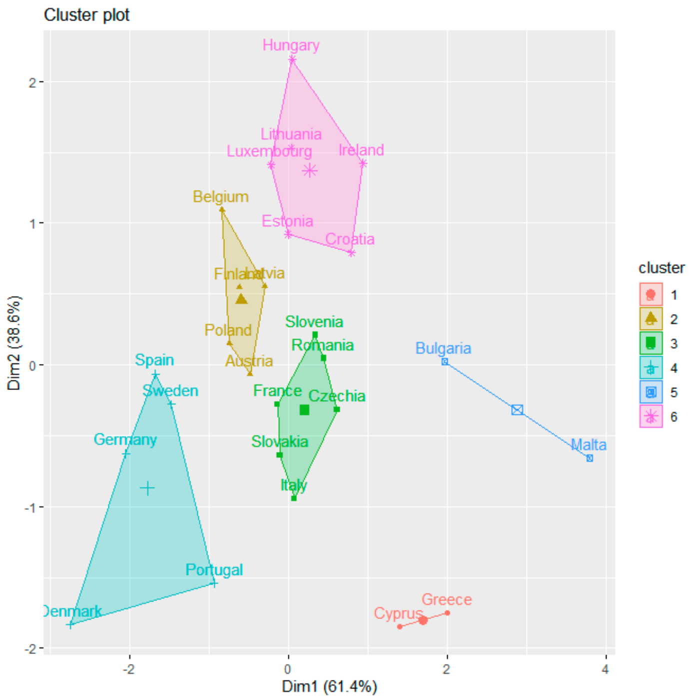

Figure 5. Visualization of EU states clustering (data for 2020). Note: Dim1 and Dim2 are as described in Figure 4. Source: own elaboration in the R package.

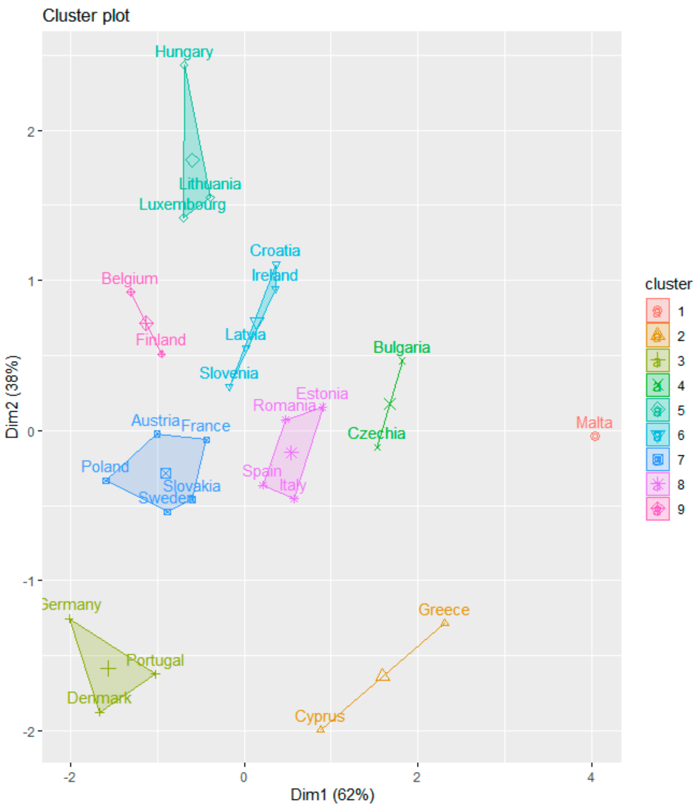

Figure 6. Visualization of EU states clustering (data for 2021). Note: Dim1 and Dim2 are as described in Figure 4. Source: own elaboration using R package.

The best division was found to be three clusters for the 2019 data. Considering the silhouette width (SW) (see Table A2), France was an outstanding observation in this division, with a negative SW value. In other words, France was the most different from the other countries in the group and was relatively close to the middle of another group. Therefore, the inclusion of France in cluster 3^{2019} should be treated with caution. The first cluster (1^{2019}) included four countries from Southern Europe (Bulgaria, Greece, Cyprus, and Malta). These countries were distinguished by a significant share of energy production costs ($ESs_1^{2019} = 61.5\%$) and a low share of transmission costs ($ENs_1^{2019} = 18.1\%$) and taxation ($ETs_1^{2019} = 20.3\%$). The second cluster (2^{2019}) included seven countries (Denmark, Germany, Spain, Italy, Portugal, Slovakia, and Sweden). The distinguishing features of this group were the highest share of taxes in the price of electricity ($ETs_2^{2019} = 45.5\%$) and a relatively low share of energy production costs ($ESs_2^{2019} = 29.2\%$). The algorithm classified the remaining countries into the largest group (3^{2019}), consisting of 15 countries. This group was characterized by the highest average share of network costs ($ENs_3^{2019} = 33.7\%$) when compared to the other groups. It is also worth noting that all averages in this group were the closest to a uniform distribution.

In the case of the results obtained for 2020, six clusters were defined. The group from the previous year 1^{2019} was divided into two parts: Greece and Cyprus (1^{2020}) and Bulgaria and Malta (5^{2020}). Cluster 1^{2020} was distinguished primarily by a low average share of network costs (ENs_1^{2020}= 15.4%) and a relatively high average share of energy production costs (ESs_1^{2020}= 57.1%). Group 5^{2020} was distinguished by the highest average share of energy production costs ($ESs_5^{2020} = 65.1\%$) but also the lowest average share of taxes ($ETs_5^{2020} = 11.2\%$), which was much lower than in the case of cluster 1^{2020}. On the other hand, in the case of the average share of network costs, group 1^{2020} had a much higher value than cluster 5^{2020} ($ENs_1^{2020} = 15.4\%$ and $ENs_5^{2020} = 23.7\%$). This change was mainly due to the fact that in Greece and Cyprus in 2020, the amount of taxes included in the final household energy price decreased significantly compared to 2019 (by 11.5% and 12.8%, respectively). Cluster 2^{2019} was also divided in the year 2020. Five countries—Denmark, Germany, Spain, Portugal, and Sweden—formed a separate cluster (4^{2020}), while Slovenia and Italy merged together with France, Czech Rep., Romania, and Slovenia, which broke away from cluster 3^{2019}, to form cluster 3^{2020}. Cluster 4^{2020} was distinguished by a very high average share of taxes in the price of electricity (ETs_4^{2020}= 49.9%). Sweden was also a leading country in energy efficiency [88]. The remaining countries from group 3^{2019} were allocated to two clusters: 6^{2020} (Estonia, Ireland, Croatia, Lithuania, Luxembourg, and Hungary) and 2^{2020} (Belgium, Latvia, Austria, Poland, and Finland). In cluster 2^{2020}, the average shares of the individual components were evenly distributed ($ESs_2^{2020} = 32.1\%$, $ENs_2^{2020} = 33.5\%$, and $ETs_2^{2020} = 34.4\%$). On the other hand, in cluster 6^{2020}, the average shares of the energy production costs and network costs were almost at the same level (ESs_6^{2020}= 38.2% and ENs_6^{2020} = 38.4%), while the average share of tax-related costs was relatively small (ETs_6^{2020} = 23.3%).

When carrying out the classification of the countries based on data from 2021, the best number of clusters was determined to be nine. This increase in the number of clusters can be interpreted as a significant increase in the diversity of the analyzed characteristics between EU countries.

The outstanding case in 2021 was Malta, classified into a single-object cluster 1^{2021}. For Malta, the component with the largest share in the unit price of electricity was production costs ($ESs_1^{2021} = 77\%$), while the smallest was taxes and other fees ($ETs_1^{2021} = 5.7\%$). In this setting, we can treat Malta as an outlier observation. Greece and Cyprus also formed one group (2^{2021}) in this division. They were distinguished by a high average share of energy production costs ($ESs_2^{2021} = 57\%$) and a low share of transmission costs (ENs_2^{2021}= 13.2%). In this ranking, Bulgaria (previously classified with Malta) together with Czech Rep. formed cluster 4^{2021}, characterized by a high average value of the share of production costs (ESs_4^{2021} =56%); however, compared to cluster 2^{2021}, it had, on average, a higher share of network costs ($ENs_4^{2021} = 24.6\%$) and a lower share of tax costs (ETs_4^{2021} = 19.2%). Denmark, Germany, and Portugal emerged from cluster 4^{2020} to form a separate group in this division (3^{2021}). This group was distinguished by the highest average value of shares of tax costs (ETs_3^{2021} = 49.2%). In addition, we observed the lowest average share of energy production costs ($ESs_3^{2021} = 29.3\%$) and a relatively low average value of the share of transmission costs ($ENs_3^{2021} = 21.5\%$) in this group.

Lithuania, Luxembourg, and Hungary were classified together into group 5^{2021}. In the 2020 ranking, these were the countries in group 6^{2020} (together with Estonia, Ireland, and Croatia). This group was distinguished primarily by the largest average share of network costs ($ENs_5^{2021} = 40.7\%$). Ireland, Croatia, Latvia, and Slovenia were assigned to cluster 6^{2021} in the 2021 classification. The defining characteristic of this group was an increased average value of the share of energy production costs ($ESs_6^{2021} = 42.4\%$). Another group with an increased average share of energy production costs was group 8^{2021}(Estonia, Spain, Italy, and Romania, with $ESs_8^{2021} = 46{,}6\%$). However, in contrast to cluster 6^{2021}, we observed a lower value for the average share of network costs ($ENs_8^{2021} = 25.4\%$; $ENs_6^{2021} = 32\%$).

The largest cluster defined for the 2021 data was 7^{2021}, into which the algorithm classified five countries (France, Austria, Poland, Slovakia, and Sweden). This cluster was notable for an increased value of the average share of tax costs ($ETs_7^{2021} = 37.8\%$). The last group in this ranking was 9^{2021}, with two countries: Belgium and Finland. In this group, all average values were distributed in the most uniform manner when compared to the other groups ($ESs_9^{2021} = 31.3\%$; $ENs_9^{2021} = 35.1\%$; $ETs_9^{2021} = 33.6\%$).

7. Results and Discussion

Our first finding is the increasing number of clusters in the classifications for subsequent years (three clusters in 2019, six clusters in 2020, and nine clusters in 2021). There are at least two possible reasons for the increasing heterogeneity of EU countries related to the analyzed variables: firstly, the economic changes caused by the broad lockdowns and closures as the result of the COVID-19 pandemic; secondly, recent work towards low-emission economies, which is directly related to the implementation of sustainable development strategies in the field of energy in EU countries. This demonstrates the increasing heterogeneity of EU countries with regard to the price structure for electricity offered to households. It is worth noting here that one element of the European Union's energy policy is to increase the share of renewable energy in total energy consumption. This is linked to, among other things, lower CO_2 emissions [89]. These authors point out that the promotion of renewable energy should be supported by appropriate policy tools, e.g., subsidies or low-interest loans. These tools can also be employed to support households.

Massive shutdowns across numerous industries aimed at limiting the spread of the SARS-CoV-2 virus have contributed to a reduction in overall electricity demand [4]. The consequence of this was a drop in price. The report in [4] indicates that in April of 2020, the monthly average prices of major European electricity markets fell significantly when compared to April of 2019, in many cases by 50% or even more. In terms of prices offered to households, the final price (per kWh) decreased or did not change (in 2020 compared to 2019) in 14 out of 27 countries, while this was the case for the *ES* component (related to production costs) in as many as 16 countries. However, due to remote work and quarantines, while the overall demand for electricity decreased, household electricity consumption increased (see [4–6]). Furthermore, in 2021, the demand for energy (energy carriers) increased significantly compared to 2020, which also explains the increase in prices. The increased demand for energy during this period can be explained by economic recovery after the lockdown period [7]. Changes in energy prices were found to affect the *ES* component (related to the cost of electricity production) to the greatest extent.

Between the years 2019 and 2020, the largest decreases in the value of the *ES* component (above 20%) were recorded in Sweden, Denmark, and Spain. In the obtained classification, these countries were assigned to the group with the lowest average share of the ES component (%*ES*) in the final price (cluster 2^{2019}, see Table 2). This decrease in the value of *ES* meant that in the classification for 2020, these countries were also assigned to the cluster with the smallest share (4^{2020}, Table 3). However, the situation in these countries changed completely in the following year, where the value of *ES* increased by over 70%, and even 120% in the case of Spain. For this reason, in the 2021 classification, the algorithm assigned these countries to completely different clusters. While Denmark remained in the cluster with the smallest share of ES in the total price (3^{2021}, Table 4), Spain was placed in a group where the share of *ES* was one of the highest (8^{2021}, Table 4). The value of *ES* in Spain has increased above the EU average and is now among the highest in the EU27. The IEA reports that electricity prices are expected to decrease in the coming years due to the penetration of low-cost sources ([90], p. 117). However, it should be kept in mind that these predictions may be disturbed in the short term due to the war in Ukraine.

The countries of southern Europe dominated among those where the value of the *ES* component was the highest, which also translates into a high share of *ES* in the final price. The breakdown for 2019 includes Malta, Greece, Cyprus, and Bulgaria (cluster 1^{2019}, Table 2); however, after two years, due to the a high share of this component in the price, Malta was moved into a separate cluster (1^{2021}, Table 4). In the case of Greece and Cyprus, significant changes were observed over time for the different components; however, the algorithm still showed that the price structure of these two countries was very similar. In Greece, the value of the ES component increased significantly (by 32%), but this was slightly offset by a decrease in taxation (by 7.5%). On the other hand, Cyprus recorded a significant decrease in transmission costs (*EN*) (by 16.8%) with a simultaneous increase in taxation and other fees (*ET*) (by 13.8%). Finally, in both countries, during these two years, the average price offered to households increased by just over 11%. Bulgaria recorded an increase of around 6% in all three components and eventually became similar to the Czech Republic in terms of price structure (4^{2021}, Table 4).

As previously mentioned, network costs (*EN*) may consist of transmission and distribution tariffs, transmission and distribution losses, network costs, after-sale service costs, system service costs, and measurement meter rental and metering costs. Therefore, they largely depend on the design and condition of available energy transmission systems. Network costs vary across EU countries. In 2021, they fluctuated between 0.0297 PPS in Cyprus and 0.0945 PPS in Belgium. In 2020, compared to 2019, the largest decreases in *EN* were recorded in Sweden and Slovenia. These were countries where the value of the *EN* component was lower than the EU average. On the other hand, the largest increases (by over 10%) occurred in Germany, Spain, Ireland, Lithuania, and Malta. Of those, only in Malta was the value of the *EN* component lower than the EU average; in other cases, it was significantly higher. Therefore, in the case of Malta, a small absolute change translated into a significant relative change. The following year, network costs fell in 17 countries, with the highest change in the Czech Republic and Malta. In general, over the two-year period, leveled network costs increased by 5.6% in the EU27, with a median of 0.4% for countries. It was recognized that the *EN* component was the most stable among all components. Therefore, it can be considered that changes in this area have the least impact on fluctuations in the overall prices of electricity offered to households.

The *ET* component (taxes, fees, levies, and charges) concerns the taxation of electricity prices and other additional charges not related to its production and transmission. The parts of this component are value-added tax (VAT), renewable taxes, capacity taxes, environmental taxes, nuclear taxes, and other taxes. This is the component that is most influenced by national governments. In particular, significant increases in electricity prices are mitigated by lowering the fees associated with this component. Poland and Spain decreased the VAT for electricity to 5%. Belgium, on the other hand, imposed a temporary cut in the domestic electricity VAT rate (from the standard rate of 21% to 6%). In Italy, the most important element of the support package is a one-off bonus of EUR 200 for 28 million workers and pensioners with incomes of less than EUR 35,000 annually, [91]. On 4th September of 2022, the German government announced an additional EUR 65 billion to relieve inflation and support households struggling with high energy prices [92]. In France, from February 2022 to January 2023, the government also reduced the electricity tax from EUR 22.50 per megawatt hour to EUR 1 for households and 50 cents for the private sector [93]. These examples of recent *ET* manipulation can be continued. EU member states should have the option to choose the tools that best suit their national situation. However, it should be borne in mind that these are temporary solutions aimed at the ongoing financial relief of households.

The highest shares of the *ET* component were observed in Germany (51.4% in 2021), Denmark (50.1%), Portugal (46%), and Poland (42.3%). The first three countries were classified together in all years ($2^{2019}, 4^{2020}, 3^{2021}$, see Tables 2–4); however, a high share of the *ES* component separated Poland from these countries. In Portugal and Germany, renewable taxes accounted for the largest share of *ET* (over 60% in Portugal and over 41% in Germany in 2021). In Denmark, on the other hand, environmental taxes made up the greatest share (almost 58% in 2021). According to the IEA report, Portugal is expected to allocate significant amounts of money (more than EUR 1 billion) to the energy sector, "with funding for sustainable mobility, energy efficiency, renewables, decarbonization and bio-economy" [94]. With reference to the data given in [95], we can observe that Portugal's carbon tax is at an average level when compared to other EU countries that have introduced this type of tax. It is worth mentioning that according to the IEA report [94], Portugal is gradually reducing exemptions from this tax. Considering the environmental changes brought about by using non-renewable energy, Germany instituted the EEG (Erneuerbare-Energien-Gesetz) surcharge, which holds a significant share in electricity taxation. The money obtained in this way is used to finance the expansion of renewables [96].

The smallest shares of the *ES* component were found in Malta (5.7%), with it being the only country where this share was less than 10%. The largest increases in the value of this component in 2019–2021 were recorded in Ireland (by 54.5%) and Poland (by 45.6%). In other countries, there were increases of no more than 16%, and even significant decreases, with the largest in Spain and the Czech Republic, by about 25%. As a result, the Czech Republic was placed in the group with lower shares of the *ET* component in the overall price in the 2021 classification.

The value of the *ET* component in Ireland was low in 2019 (0.0336 PPS). Thus, the increase of 54% (to the level of 0.0519 PPS in 2021) did not cause such a significant change in the structure of electricity prices, as was the case in Poland. Poland was finally classified into a group where the share of this component was dominant (7^{2021}, Table 4). Poland is the only country in which the share of solid fossil fuels in gross electricity production was greater than 40% (68% in 2020, see [3]). Taking into account the increase in the prices of raw materials used to produce electricity, as well as the increase in the prices of CO_2 emission permits and the reduction in their volume, final prices in Poland may continue to increase significantly, in particular, the value of the *ES* component [97].

The final results obtained indicate that it is unlikely that the considerable heterogeneity in EU countries will decrease due to the structure of electricity prices. Country-level actions aimed at limiting the negative impact of rising energy prices on society will result in large differences within the *ET* component. In addition, compliance with the requirements of the "Fit for 55" package, which implies that an EU target to reduce net greenhouse gas emissions by at least 55% by 2030 should also be considered. Steps taken in this direction vary from country to country and are associated with high ET values. The funds obtained in this way are allocated, inter alia, to an expansion of renewables, as in the case of Germany, Denmark, and Portugal. In addition, countries where the energy system has not yet been significantly transformed into a low-emission system must take into account the additional costs of purchasing CO_2 emission allowances (as in the case of Poland).

8. Conclusions

Perturbations, not only economic, resulting from the COVID-19 pandemic and war in Ukraine have contributed to significant increases in energy prices, which have resulted in increased electricity prices. Increases in electricity prices should be considered from both economic and social dimensions, as high energy prices directly increase the number of individuals at risk of energy poverty and indirectly contribute to increases in the prices of goods (including basic goods such as food).

Abbnet [98] reported that EU countries had agreed that the negative effects of this situation should be counteracted; however, no common position on the related actions has been formulated. Therefore, EU member states can choose the tools that best suit their national situation. Most countries have temporary measures in place to protect households from higher bills, implemented as early as 2021. These mainly include energy tax cuts and subsidies for households (see [98]).

An additional problem for many countries, especially those in which the energy sector is largely based on coal, are the necessary changes in the framework of adaptation to the "Fit for 55" requirements and the rising prices of CO_2 emission allowances. According to the information provided by the German Federal Ministry for Economic Affairs and Climate Action, "the total volume of allowances available in a year in EU emissions trading (the "cap") will be cut annually from 2021 by a linear reduction factor (LRF) of 2.2 percentage points, rather than the current rate of 1.74 percentage points" [97]. The LRF specifies the annual decrease in allowances delivered to the market through free allocation or auction [99].

The variety of tools used to mitigate the increase in electricity prices and the actions taken towards low-carbon economies resulted in a significant increase in the heterogeneity of EU countries with respect to the price structure of electricity offered to households over the period studied here (2019–2021). Both the post-pandemic crisis and advanced "low-carbon economies" will support nationally diversified energy policies. It is therefore expected that in the upcoming years, the heterogeneity of EU countries will not decrease, rather, a further increase is likely. The *ET* component is the main reason for this heterogeneity, as it is highly influenced by national policymakers. In addition, the new member states of Eastern Central and Eastern South Europe are more exposed to increasing diversity. As proven in the 2021 classification, these countries differed from the countries that they were clustered with in 2020.

As mentioned in the discussion, the obtained final results indicate that a significant reduction in heterogeneity among EU countries with respect to the structure of electricity prices should not be expected. Despite the numerous regulations introduced by the European Commission, EU countries remain economically and legally diverse. Additionally, there are significant variations in implementable political programs. This results in different factors influencing the level and structure of electricity prices in different countries. Consequently, the pricing policies implemented will continue to be highly diverse across the EU. Short-term actions regarding prices mainly focus on changes within the *ET* component (taxes and other fees), which is evident in current observations. In the long term, reductions in network cost (*EN* component) and a search for cheaper energy sources (*ET* component) can be planned. It is worth noting at this point that the reduction in network costs is a highly complex problem. To a large extent, these costs depend on the ways in which electricity is distributed, the state of the transmission networks (losses in these networks, transmission stability, etc.) or the costs incurred for modernization and investment. This results in additional variables that have a significant impact on electricity price variability across EU countries. We believe that a combination of several actions, including the diversification of energy sources, ensuring energy security, technological innovation, and improving energy efficiency, can play an important role in shaping long-term pricing strategies. Therefore, further research on electricity prices should also focus on considering these factors.

The issue of when households will be treated in a similar way across the EU in terms of electricity prices remains open, and in view of the 2022 situation, it may not be solved any time soon.

EU countries agree that the negative effects of this situation should be counteracted; however, no common position on the best actions has yet been formulated. Therefore, EU member states can choose the tools that best suit their national situation. Most countries have temporary measures in place to protect households from higher bills, introduced as early as 2021. These include mainly energy tax cuts and subsidies for households (see [98]).

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Appendix A

Table A1. Silhouette width and silhouette width averages in EU country clusters.

	2019	2019	2020	2020	2021	2021
GEO	**Cluster**	**sil_width**	**Cluster**	**sil_width**	**Cluster**	**sil_width**
Belgium	3	0.6514	2	0.4515	9	0.8016
Bulgaria	1	0.5917	5	0.6981	4	0.6544
Czech Republic	3	0.2585	3	0.6384	4	0.7177
Denmark	2	0.7869	4	0.7802	3	0.8810
Germany	2	0.7784	4	0.7697	3	0.6549
Estonia	3	0.8120	6	0.3700	8	−0.2300
Ireland	3	0.1007	6	0.7621	6	0.6819
Greece	1	0.7726	1	0.8947	2	−0.1847
Spain	2	0.8438	4	0.3233	8	0.7024
France	3	−0.2326	3	0.4931	7	0.4880
Croatia	3	0.6535	6	0.5298	6	0.5171
Italy	2	0.3900	3	0.4673	8	0.7217
Cyprus	1	0.7566	1	0.9332	2	0.5038
Latvia	3	0.7527	2	0.6399	6	0.7564
Lithuania	3	0.8098	6	0.7435	5	0.8226
Luxembourg	3	0.7183	6	0.5109	5	0.6554
Hungary	3	0.7614	6	0.7095	5	0.8258
Malta	1	0.8102	5	0.6372	1	0.0000
Austria	3	0.2409	2	0.3511	7	0.3955
Poland	3	0.4003	2	0.7406	7	0.3655
Portugal	2	0.8328	4	0.4504	3	0.7426
Romania	3	0.6428	3	0.6256	8	0.6212
Slovenia	3	0.7547	3	0.3913	6	0.3871
Slovakia	2	0.6244	3	0.6471	7	0.6953
Finland	3	0.5152	2	0.8305	9	0.7844
Sweden	2	0.5083	4	0.4927	7	0.6178
1	4	0.733	2	0.914	1	0.000
2	7	0.681	5	0.603	2	0.160
3	15	0.523	6	0.544	3	0.760
4			5	0.563	2	0.686
5			2	0.668	3	0.768
6			6	0.604	4	0.586
7					5	0.512
8					4	0.454
9					2	0.793
Average		0.645		0.649		0.524

Source: own calculations using R package.

Table A2. SI index values for EU countries.

Number of Clusters	2019	2020	2021
2	0.5645	0.5136	0.5100
3	0.5975	0.5057	0.5376
4	0.4746	0.5533	0.5154
5	0.3597	0.5484	0.4421
6	0.4169	0.6108	0.3735
7	0.4793	0.5108	0.4280
8	0.4557	0.4390	0.4924
9	0.4025	0.5053	0.5608
10	0.4570	0.4882	0.5352
11	0.4103	0.5259	0.5206
12	0.3933	0.5379	0.4845

Source: Own calculations using R package.

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