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DRIVERS FOR RENEWABLE ENERGY CONSUMPTION IN EUROPEAN UNION COUNTRIES. A PANEL DATA INSIGHT

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Abstract

Renewable energy sources play an essential role in the broader context of environmental protection and the fight against the effects of climate change. At the European level, the need to increase the proportion of energy generated by renewable resources is formalised through the Renewable Energy Directive (2009/28/EC), which was updated in 2018 and became legally mandatory starting from June 2021. The European Green Deal, adopted in 2019, highlights the role of energy generated from renewable sources in fulfilling more complex objectives recognised at the international level. Within this context, in this study, we investigate the link between renewable energy consumption by sector and other critical indicators in the energy sector, representing energy productivity, intensity, efficiency, import dependency, research and development (R&D) allocations, and energy-related tax revenues, for the period 2004-2020. We employed a panel data approach for European Union member states, Central and Eastern Europe and Western Europe countries separately. The empirical results confirm the different conditions for the two groups of countries, suggesting the possibility of designing specific energy policies. We emphasise the positive role of R&D in both categories of member states.

Keywords: renewable energy, energy policy, European Union, panel data.

JEL Classification: Q20, C23, Q40, R58.

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Introduction

In the European Union, renewable energy consumption has been promoted for a long time. In 1991, a tariff that encouraged the use of renewable energy was introduced in Germany (Peter et al., 2015). A target of 12% renewable energy in the European Union was established in 1997 (European Union, 1997). This action was followed in 2001 and 2003 by introducing directives for energy from renewable sources and national targets for electricity and transport, respectively.

In 2009, the Renewable Energy Directive (2009/28/EC) was adopted, through which its role in the economy and society is recognised as part of the energy policy (European Parliament and the Council of the European Union, 2009). The Directive was updated in 2018, establishing targets (32% consumption of renewable energy sources by 2030) and rules for renewable energy sources in the transport, heating, and cooling sectors. It also considers cost reductions, barrier removals, investment stimulation, and involvement of consumers and businesses in the process of the clean energy transition. This version became legally mandatory in June 2021 and sustained the emissions reduction objectives integrated into the Paris Agreement signed in 2015.

The United Nation's 2030 Agenda and the sustainable development goals (United Nations General Assembly, 2015) are transposed into the European strategy through the European Green Deal (European Commission, 2019) that encompasses a set of transforming policies for the European Union countries. Renewable energy sources are considered necessary, and an intelligent integration is proposed.

In July 2021, a revision of the Renewable Energy Directive (European Commission, 2021) was proposed, aiming for synchronisation with the European Green Deal, considering a new target of 40% for renewable energy consumption. In less than a year, the target was increased to 45% by 2030, through the REPowerEU plan (European Commission, 2022). These measures are taken to reach the goal of climate neutrality by 2050. The adoption is expected in the first quarter of 2023. The new targets for renewable energy determined an increase in the European renewable electricity capacity forecast for 2022-2027 by 60%, double compared to the previous five-year period (International Energy Agency, 2022). Germany, Spain, France, the Netherlands, Poland, the United Kingdom, and Turkey are the countries that amount to 75% of the expansion.

An analysis for 2010-2018 highlighted the leading position of the European Union in the renewable energy sector (European Commission et al., 2022). In 2018, the export was 5.4 billion euros, while the market shares amounted to 67% for wind energy, 42% for geothermal, and 39% for hydropower. In a recently published report, the International Energy Agency recognised that the threat of the energy crisis, the 14th Five-Year Plan and market reforms in China, the REPowerEU plan in Europe, and the Inflation Reduction Act in the United States contributed to the substantial revision of the renewable energy increase forecast (International Energy Agency, 2022). For the next five years (2022-2027), it is estimated that an advance of 85% will take place, considering the last similar period, with 30% more than in the previous yearly report. The report captures specific barriers for developed countries (implementation, expansion of infrastructure) and emerging countries (uncertainty of policies and regulations) in developing the capacity to produce energy from renewable sources.

A bibliometric analysis suggested that only on the Web of Science platform are there more than 76,000 articles on the subject of "Renewable Energy" (Bortoluzzi, Correia de Souza and

Furlan, 2021), reflecting the importance of this domain in academia. According to the authors, the first research articles published in this area date back to 1974 and 1976. Another literature analysis concerning renewable energy sources and geopolitics reveals that this kind of energy is beneficial for security and peace at the international level (Vakulchuk, Overland and Scholten, 2020).

Previous research results confirm their role in environmental protection and economic growth in emerging economies (Boubaker and Omri, 2022). The beneficial role of renewable energy for the environment was demonstrated by the G-7 group of countries, one of the most developed economies (Wang, Rehman and Fahad, 2022), while (Purica et al., 2020) emphasises their role in the energy system transformation process. Moreover, energy companies are sensitive to systemic and regulation concerns (Lupu et al., 2021).

Considering the importance of this energy source and its increasing role in alleviating energy insecurity, in this article, we propose an empirical analysis to assess the drivers for consumption by sectors, in the countries of the European Union, for the period 2004-2020, employing a panel data approach. Previously, such a methodology was used by (Popescu et al., 2018) to highlight the important variables in Europe for defining a new energy paradigm. For our analysis we consider other critical indicators in the energy sector (total, in transport, electricity, and in heating and cooling), including energy productivity, intensity, efficiency, import dependency, research and development (R&D) allocations, and energy-related tax revenues, as well as gross domestic product (GDP) per person. Our contributions to the economic literature consist in investigating these relations for two groups of countries from the European Union, Central and Eastern European, and Western European member states, highlighting the differences between them. We, therefore, consider developmental differences and use the most recent statistical data available. Thus, economic and energy policies can be directed to the elements representing the main drivers of energy consumption from renewable sources by sector and group of countries.

Furthermore, the article is structured as follows. The primary economic literature on renewable energy sources is reviewed in Section 2. Section 3 presents the statistical data and the methodology employed. Section 4 provides the empirical results obtained and the subsequent discussion. The final section summarises the main conclusions.

1. Review of the scientific literature

Renewable energy sectors have been an interesting research subject from 1974 to 1976 (Bortoluzzi, Correia de Souza and Furlan, 2021). The published research articles confirmed the importance of this sector in economic, environmental, and social evolution, with discussions being divided into various subfields, influences and effects. However, the results obtained in previous research are fragmented, and there is a need for consensus on the determinants (Bourcet, 2020).

The drivers of this energy source consumption were analysed for Brazil, Russia, India, China, and South Africa (BRICS countries), using a quantile panel regression (Sachan et al., 2023). For these countries, two specific indices (environmental policy stringency and human development) consistently impact renewable energy consumption. In the countries of the Middle East and North Africa (MENA countries), the results of a panel quantile approach reveal that financial development positively influences energy production from renewable

resources. At the same time, the political stability index is heterogeneous (Belaid, Elsayed and Omri, 2021).

At the European level, policy reliability is considered to play a vital role in the development of renewable energy technologies (Shivakumar et al., 2019). The critical role of policies for renewable energy consumption was also confirmed for net European energy-importing states, along with lobbying and education, that complete the public awareness (Marra and Colantonio, 2021). Considering a composite sustainability index, Turtorean, Chirilă and Chirilă (2022) evidenced that at the European Union level there are clusters of countries with the similar state. After analysing the energy transition in 42 European countries from 1990-2018, Apostu, Panait and Vasile (2022) emphasised the differences among analysed economies. The authors draw attention to the fact that establishing less ambitious goals in countries not members of the European Union affects the energy transition process.

For 38 countries around the globe and 20 years (1990-2010), Aguirre and Ibikunle (2014) demonstrated that environmental issues were more significant than energy security for renewable energy development. At the same time, countries that have fewer traditional resources make a tremendous effort to develop technologies in this field. At the same time, policy design failure (uncertainty and discontinuity) hinders renewable energy investments. Analysing the renewable energy development in 26 European Union countries for twenty years (1995-2014), Papież, Śmiech and Frodyma (2018) confirmed that countries that lack resources had developed more energy production from renewable sources. Marques and Fuinhas (2011) used a dynamic panel data approach for 24 European countries to assess the drivers of renewable energy development over the period 1990-2006. They concluded that the previous use of renewable energy significantly impacts the current level and that awareness and carbon emissions targets do not motivate the transition toward alternative sources.

Increased carbon emissions and trade openness are considered essential drivers for energy consumption from renewable sources in 64 countries from 1990-2011 (Omri and Nguyen, 2014). For a similar period (1990-2014), but for transition economies, more precisely for 27 countries from Central and Eastern Europe, the Caucasus and Central Asia, Przychodzen and Przychodzen (2020) evaluated the determinants for renewable energy generation using panel data model. They found that increases in economic growth, unemployment, and government debt are stimulating renewable energy production and Kyoto Protocol implementation. Contrary to previous research, the authors concluded that increasing carbon emissions negatively affects renewable energy development. However, these are specific considerations for post-communist countries that are suggested to be included in policy design. For example, the role of energy consumption for the economic paradigm in Romania is analysed by (Popescu et al., 2019).

Economic growth stimulates the development of the renewable energy sector in European Union countries, but environmental and energy taxes have a negative influence (Dogan et al., 2023). The analysis concerns 25 European countries, over the 1995-2019 period. Fiscal decentralisation, political risk, and R&D for renewable energy encourage renewable energy development in the case of seven Organization for Economic Cooperation and Development (OECD) countries over the period 1990-2018 (Su, Umar and Khan, 2021). The authors applied a panel data approach.

Marques, Fuinhas and Pires Manso (2010) proposed a threefold factor approach to analyse the drivers of renewable energy consumption in European countries: political, socioeconomic, and country-specific. They welcomed the initiative of promoting renewable energy for electricity production through a European Directive (European Parliament and the Council of the European Union, 2001). An interesting study that analyses the link between renewable energy consumption and its drivers (energy efficiency, energy intensity, R&D allocations for renewable energy, and GDP) was published by Alola, Olanipekun and Shah (2023). The analysis is performed for 12 countries which have been previously labelled as successful in energy transition, seven of which are part of the European Union (Austria, Canada, Denmark, Finland, France, Germany, New Zealand, Spain, Sweden, Switzerland, the United Kingdom, and the United States). The studied period was 1990-2019, and the authors applied a panel data approach. The empirical results show that all considered indicators influence the increase in energy consumption obtained from renewable sources.

Although the literature on renewable energy is generous, the results are fragmented. No specific studies analyse European Union countries separately on the two groups, Central and Eastern European and Western European member states, as they have specific features (Dinu, 2016). Moreover, even if there are studies that separately consider the indicators proposed in this paper for the explanatory part, they have not been explored together in previous studies. Even if previous research is done for long periods, it refers to earlier periods, and changes in recent years make updates of analyses necessary. Furthermore, the business environment in the European Union is characterised by increased turbulence that affects the development model (Miron et al., 2019).

2. Research methodology

2.1 Data description

To investigate the relationship that exists between renewable energy consumption by sector and possible driver indicators for renewable energy development, we considered the period 2004-2020 for our analysis regarding European Union countries. The research covers two groups of countries, respectively, Western European (Austria, Belgium, Cyprus, Denmark, France, Finland, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Spain, Sweden, and the United Kingdom), and Central and Eastern European (Bulgaria, Czech Republic, Croatia, Estonia, Latvia, Lithuania, Hungary, Poland, Romania, Slovenia, Slovakia) keeping in mind the differences between them. For this reason, the period analysed starts in 2004, when most countries in Central and Eastern Europe joined the European Union, while Bulgaria and Romania joined the Union three years later, in 2007. The year 2014 represents a moment from which the Central and Eastern European states officially align themselves with the policies of the Union. Renewable energy consumption measures its share in gross final energy consumption, as the Renewable Energy Directive specifies. The gross final energy consumption represents the energy used by end-consumers to which the grid losses and self-consumption of power plants are added.

Considering the suggestion of Marques, Fuinhas and Pires Manso (2010), our driver indicators may be divided into three categories: political, socioeconomic and country-specific. The political factors count for political will and may include regulations, financial and tax benefits, and allocation to support some economic objectives. From this perspective, we assay the energy-related tax revenue as per cent of total environmental tax revenue

(government instrument to set the relative prices) and R&D allocations, respectively, government budget allocations for R&D for environment and energy, and for renewable, as per cent of total energy public R&D allocations. The environmental and energy tax issue was considered for European Union countries by Dogan et al. (2023), while R&D was assessed by Su, Umar and Khan (2021) for selected OECD countries and Alola, Olanipekun and Shah (2023) for prosperous countries in the energy transition. The socioeconomic factors may include economic growth, energy needs as reflected by energy productivity, energy intensity and energy efficiency. In this category, we have embedded indicators such as real GDP per person, energy intensity, energy import dependency, and energy efficiency, as primary and final energy consumption, in line with Europe 2020-2030 targets. A detailed analysis of European net energy importing countries was performed by Marra and Colantonio (2021), while energy intensity and efficiency were considered by Alola, Olanipekun and Shah (2023). The country-specific factors may refer to the geographic area. In this respect, we divided the European Union member states into Western and Central and Eastern European countries. The frequency of used statistical data is annual, and all implied indicators are presented in table no. 1.

Table no. 1. Description of the used variables

Variable	Description	Source
Share of renewable energy in gross final energy consumption by sector (renewable energy sources, renewable energy sources in transport, renewable energy sources in electricity, renewable energy sources in heating and cooling)	The indicator belongs to the set of indicators reflecting the European Union Sustainable Development Goals (SDG). Have a role in monitoring improvements of SDG 7 (affordable and clean energy) and SDG 13 (climate action), transposed into the European Green Deal that aims for climate neutrality by 2050 in the European Union. A target of 20% share of renewable energy in final energy consumption by 2020 was set in the strategy Europe 2020. The revised Renewable Energy Directive increased the target to 32% by 2030. The Next Generation EU plan, part of the 2021-2027 cohesion policy funds, financially supports investments in the development of energy from renewable sources.	Eurostat, (Eurostat, 2022d)
Energy-related tax revenue, per cent of total environmental tax revenue	The government uses environmentally related taxes to establish relative prices. This kind of tax is constructed considering the environmental domain, energy.	OECD, (OECD, 2022)
Government budget allocations for R&D (GBARD), environment	GBARD represent Government financial support for R&D through different activities, highlighting its priorities. Besides public establishments, it concerns R&D in private areas such as business companies, non-profit organisations, and higher education institutions. We considered two primary socioeconomic objectives linked to our research domain: environment and energy.	Eurostat, (Eurostat, 2022c)
Government budget allocations for R&D (GBARD), energy		
Renewable energy public research, development, and demonstration projects (RD&D)	Represents government financial support for RD&D in renewable energy domain,	OECD, (OECD, 2022)

Variable	Description	Source
budget, per cent of total energy public RD&D	including hydro, geothermal, solar, wind and other.	
Real GDP per person	Economic output per inhabitant.	OECD, (OECD, 2022)
Energy productivity	GDP per unit of total primary energy supply (TPES).	OECD, (OECD, 2022)
Energy intensity	Represent the need for energy in the economy (TPES per person).	OECD, (OECD, 2022)
Energy efficiency, primary energy consumption (Europe 2020-2030)	Monitor progress in meeting Europe's energy efficiency targets in 2020 (European Parliament and the Council of the European Union, 2012) and 2030 (European Parliament and the Council of the European Union, 2018). The targets are different for primary and final energy consumption.	Eurostat, (Eurostat, 2022a)
Energy efficiency, final energy consumption (Europe 2020-2030)		
Energy imports dependency	Represents the share of needs for total energy in a country that are met by imports (net imports/gross available energy). Negative values mark net exporters.	Eurostat, (Eurostat, 2022b)

2.2 Methodology approach

Our methodology is designed in keeping with the recommendations of (Wooldridge, 2009). We, therefore, develop an analysis in which data is organised in time series panels. A symbolic description of this approach is the following:

$$y_{jt} = X_{jt}\beta + \alpha_j + \mu_{jt} \quad (1)$$

for $t = 1, \dots, T$ and $j = 1, \dots, N$.

Under this framework, the variable y_{jt} is the dependent one, representing one time series (hence the notation t) for each country j . X represents the set of independent variables, while β corresponds to the estimated coefficients. Parameters α_j represent the so-called “individual effects”, i.e., country effects. In contrast, parameters μ_{jt} denote the error specific to each pair country – moment in time, i.e., the so-called “idiosyncratic effects”.

Following the steps set forth by (Wooldridge, 2009), our analysis takes into account three possible specifications for the estimation of these parameters: Pooled Ordinary Least Squares (OLS), Fixed Effects (FE), and Random Effects (RE) models. The main assumptions of the Pooled OLS are the same as in the linear regression case. They encompass the hypotheses of linear dependence, exogeneity, constant variance, and no autocorrelation for residuals (error terms). The critical assumption of exogeneity relies on the request that the explanatory variables should have no linear dependence (covariance) with the unobserved independent variables. This condition is specified in the equation $Cov(X_{jt}, \alpha_j) = 0$. Another condition for the OLS specification would be that the individual effects (depicted by α_j coefficients) should not be serially correlated over time. Such an event would render the pooled OLS unavailing.

In order to identify the best approach, we initially estimate the Pooled OLS. On its output, we test for heteroscedasticity through the White and Breusch-Pagan tests and for

autocorrelation through the Durbin-Watson test. This investigation produces an inference on the extent to which the assumptions of linear dependence encompassed by OLS hold. In case tests provide information that these conditions do not hold, we investigate the possibility of Fixed Effects (FE) or Random Effects (RE) specifications.

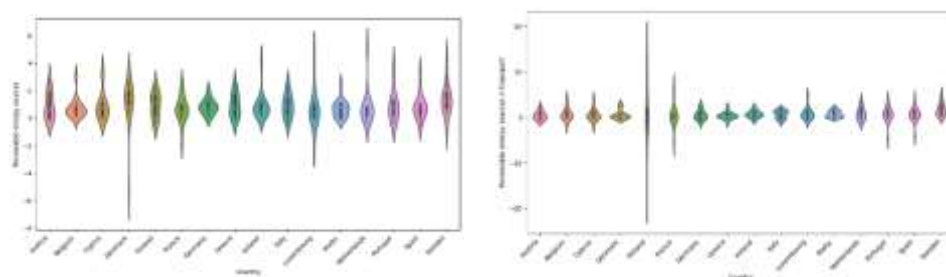
Under the former, we are facing a situation in which the unobserved variables produce country effects that do not vary over time. In this case, a linear dependence between the explanatory variables that are used in the regression and the α_j parameters are different from zero. However, the deficiency of this approach is that this possible connection may be observed only within entities (countries in our case). On the contrary, the Random Effects model accommodates the possibility for these "country effects" to change with time, and therefore allows the estimation procedure to alter from the Pooled OLS case to the Fixed Effects case. Hence, the literature that uses this methodology usually states that this approach allows the shift from "between" to "within" effects.

In order to identify the estimation procedure best suited to our analysis, we use the Hausman test, which considers that the covariance mentioned above is not different from zero under the null hypothesis. Therefore, after running the Pooled OLS estimation for each panel representation in our analysis, if we find evidence of violation of its conditions, we use the Hausman test to check whether the RE model or the FE model is better for our data.

We developed an algorithm following these steps to verify the appropriate model in panel data instances. Each such instance uses one of the four dependent variables and the whole set of explanatory variables, and the analysis is performed separately on Central and Eastern European countries and Western European countries. We, therefore, repeated the procedure eight times. We noticed that the Pooled OLS model was picked as the best fit by our algorithm each time.

3. Results and discussion

We performed the methodology as mentioned earlier for each of the four dependent variables: renewable energy sources, renewable energy sources in transport, renewable energy sources in electricity, and renewable energy sources in heating and cooling. The rest of the indicators are included in the set of explanatory variables. Figure no. 1 presents the distributions of first differences for 2004 – 2020 for Western European countries, while figure no. 2 displays those for Central and Eastern European countries.



(a) Renewable energy sources

(b) Renewable energy sources in transport

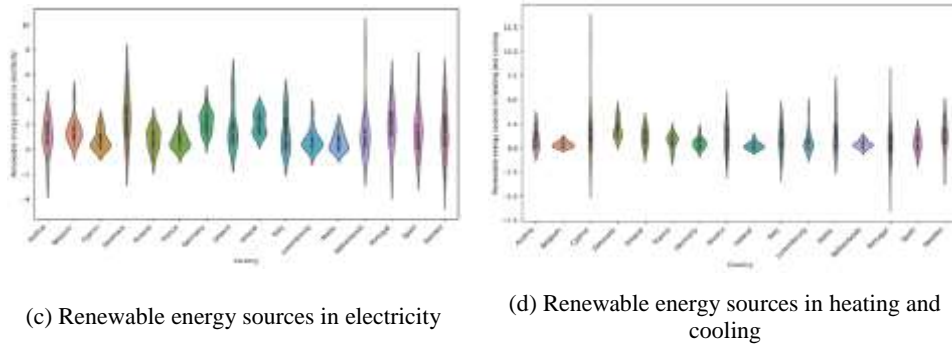


Figure no. 1. Distributions of first differences for the period 2004-2020 for Western European countries

We observe extreme values for Denmark and Luxembourg in the case of renewable sources, for Finland in the case of renewable energy sources in transport, for Denmark, the Netherlands, Portugal, Spain and Sweden in the case of renewable sources in electricity, and Cyprus and Portugal in the case of renewable sources in heating and cooling.

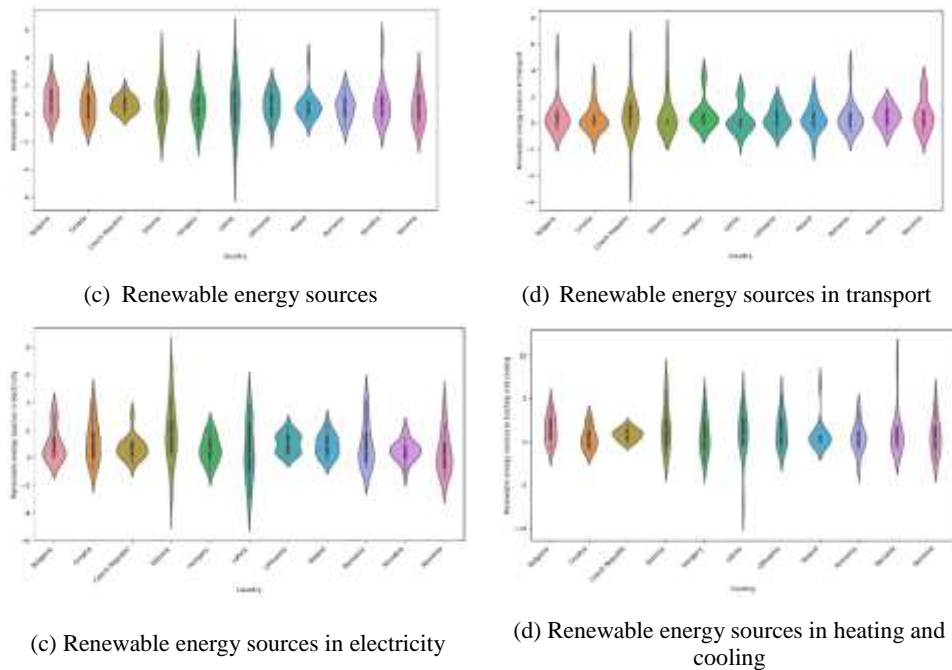


Figure no. 2. Distributions of first differences for the period 2004-2020 for Central and Eastern European countries

For the group of Central and Eastern European countries, we observe extreme values for Latvia in the case of renewable sources, for the Czech Republic and Estonia in the case of renewable energy sources in transport, for Estonia and Latvia in the case of renewable sources in electricity, and Latvia and Slovakia in the case of renewable sources in heating and cooling.

Our results highlight the importance of different drivers for the two groups of countries. The results for Western economies are presented in Table no. 2, while those for Central and Eastern European countries are exposed in Table no. 3. To obtain these results, we used panel regressions with specifications that included all independent variables (presented in the first column). Applying the algorithm mentioned in the previous section led to the use of Pooled OLS regression for all cases, both for Central and Eastern European and Western European economies.

Table no. 2. Results for Western European countries

Exogenous variables (p-values)	Dependent variables			
	Renewable energy sources	Renewable energy sources in transport	Renewable energy sources in electricity	Renewable energy sources in heating and cooling
Energy-related tax revenue, % total environmental tax revenue	-0.030	-0.078*	0.070	0.044
Government budget allocations for R&D, environment	-0.047	-0.076	-0.042	0.020
Government budget allocations for R&D, energy	0.081**	0.164***	-0.055	0.004
Renewable energy public RD&D budget, % total energy public RD&D	-0.010	-0.001	-0.018	0.023
Real GDP per person	-0.114	0.089	-0.473***	0.109
Energy productivity	-0.102	-0.064	0.463***	-0.039
Energy intensity	0.310	0.241	0.386	-0.081
Energy efficiency, primary energy consumption (Europe 2020-2030)	-0.652***	-0.460**	-0.274	0.029
Energy efficiency, final energy consumption (Europe 2020-2030)	-0.027	-0.077	-0.127	-0.261
Energy imports dependency	-0.174**	-0.024	-0.078	-0.160*

Note: * significance at 10%, ** significance at 5%, *** significance at 1%

In the case of West European countries, for renewable energy sources, energy efficiency, primary energy consumption is most significant and has a negative relationship. For this category, a negative relationship has the energy imports dependency, and a positive one is observed for the government budget allocations for R&D, energy. This indicator has a significant positive relationship with renewable energy sources in transport. In contrast, energy efficiency, primary energy consumption, and energy-related tax revenue, percent of total environmental tax revenue, have a negative influence. Renewable energy sources in electricity are positively explained by energy productivity, and negatively by real GDP per person. For renewable energy sources in heating and cooling, energy import dependency has a negative impact.

Table no. 3. Results for Central and Eastern European countries

Exogenous variables (p-values)	Dependent variables			
	Renewable energy sources	Renewable energy sources in transport	Renewable energy sources in electricity	Renewable energy sources in heating and cooling
Energy-related tax revenue, % total environmental tax revenue	0.035	-0.147	-0.237***	-0.096
Government budget allocations for R&D, environment	-0.043	0.150	0.010	0.008
Government budget allocations for R&D, energy	0.143**	0.211	0.087**	0.120*
Renewable energy public RD&D budget, % total energy public RD&D	-0.124	0.097	-0.067	-0.028
Real GDP per person	0.513	0.355	-0.374	0.338
Energy productivity	-0.855	-0.572	0.272	-0.591
Energy intensity	-1.325	-0.756	0.396	-0.993
Energy efficiency, primary energy consumption (Europe 2020-2030)	0.617	0.232	-0.184	0.794
Energy efficiency, final energy consumption (Europe 2020-2030)	-0.368**	-0.105	-0.262	-0.525***
Energy imports dependency	0.071	0.041	0.009	0.279**

Note: * significance at 10%, ** significance at 5%, *** significance at 1%

Regarding the results for Eastern European countries, for renewable energy sources, government budget allocations for R&D, energy has a positive influence, while energy efficiency, final energy consumption has a negative impact. In the case of renewable energy sources in electricity, energy-related tax revenue, per cent of total environmental tax revenue, has a significant negative influence, and government budget allocations for R&D, energy, have a positive one. For renewable energy sources in heating and cooling, energy efficiency, final energy consumption has a strong negative impact. In contrast, energy import dependency and budget allocations for R&D, energy have a positive influence on renewable consumption.

We observe only a few similarities and more differences when comparing the empirical results for the Western and Central and Eastern European countries. In Western countries, there are more significant relations, which are more negative than positive, compared to the other group of states. For both groups, the government budget allocations for R&D, energy represents a stimulative element for renewable energy consumption.

However, when separated by sector, in Western economies, the influence is significant for renewable energy sources in transport, while for others is significant for electricity and heating and cooling. Energy-related tax revenue, as percent of total environmental tax revenue, hinders the development of renewable energy but is more significant in the case of

Central and Eastern European countries (for electricity case); in Western economies, the significant negative relation is visible for renewable energy sources in transport. Energy import dependency has a negative impact in the Western hemisphere (for renewable energy sources and renewable energy sources in heating and cooling) and a positive one in the Central and Eastern parts (renewable energy sources in heating and cooling).

From the multitude of analysed elements, political factors had a similar influence on the groups of countries analysed, motivating the construction of a European policy. Appreciation of the European directives for renewable energy was previously mentioned by Marques, Fuinhas and Pires Manso (2010). The most evident similarities were observed for the government budget allocations for R&D, energy, which has a significant positive influence in Western and Central and Eastern European countries. Because they foster the consumption of energy obtained from renewable sources, the policy design has to consider this driver an important accelerator. Our results are in line with previous work (Su, Umar and Khan, 2021; Alola, Olanipekun and Shah, 2023), confirming the crucial role of R&D for renewable energy sector advancement. This research can be extended with an analysis that will concern the drivers for an increase in R&D expenditure related to energy issues while controlling for specifics of different countries, as addressed by (Hurduzeu et al., 2022). The current energy-related tax status is hampering renewable energy, suggesting a remodelling of the fiscal stimulus packages. The negative influence of energy tax on European countries was previously documented by Dogan et al. (2023).

If for the countries that recorded the highest appreciation in the energy transition, energy efficiency proved to play an important role, in the groups of countries analysed, it has a negative influence, but differentiated into the two types: energy efficiency, primary energy consumption for the Western part, and energy efficiency, final energy consumption, for Central and Eastern European countries. These results may be connected with other findings that emphasise the importance of the previous use of renewable energy as a driver for future development (Marques and Fuinhas, 2011).

Considering the differences and similarities between countries seems to be important for the formulation of strategies for the development of the energy sector obtained from renewable sources. This idea is fundamental in the context where the role of policies in developing the renewable energy sector has been emphasised by Shivakumar et al. (2019) and Marra and Colantonio (2021). Moreover, the IEA draws attention in the latest renewable energy report to the harmful role of policy and regulatory uncertainty, especially in emerging countries.

Conclusions

This study examines political, socioeconomic, and country-specific factors that influence renewable energy consumption by sector in European Union countries. The contributions to the economic literature consist in investigating the relationships and highlighting the similarities and differences for the member states of Central and Eastern Europe and those of Western Europe, but also between the sectors of activity, considering the differences in development, and using the latest data in the analysis statistics. The empirical results highlight the importance of some drivers for the renewable energy consumption development. Overall, the political factors proved to have similar effects on the two groups of countries, confirming the need for policy at the European level. Government budget allocations for research and development, energy, have an important role in both groups of

countries, being an essential element for shaping renewable energy support policies. On the other hand, our results bring another element of novelty, highlighting several differences when we analyse the empirical results for the two groups of countries. For example, although government budget allocations for research and development, energy are mobilising for increasing energy consumption from renewable sources, there are differences between countries by types of sectors. The results obtained highlight the fact that, in Western countries, a significant impact is observed for renewable energy sources in transport, and in the case of Central and Eastern European countries, it is considerable for electricity, heating and cooling. In both cases, energy-related tax revenues as a percentage of environmental revenues inhibit the growth of the renewable energy sector but are more important in the case of Central and Eastern European countries for electricity, while in Western economies, the significant negative relationship is observable for renewable energy sources in transport. Another difference highlighted by the analysis is the dependence on energy imports, which has a negative impact in Western countries and a favourable one in Eastern countries.

The obtained results may have managerial implications, being useful for the formulation of economic and energy policies; In this way, measures can be taken to stimulate the main drivers or to mitigate the effect of the inhibitors for the consumption of energy from renewable sources, by sector and group of countries. Highlighting the development enhancers using recent statistical data and the differences and similarities between groups of countries can contribute to the construction of future policies, considering specific characteristics.

One of the main limitations of our study is the lack of a longer sample size for the data we used (2004-2020). The choice of our methodology was determined by this fact, as panel data analysis manages to overcome small sample problems through cross-sectional data expansion. Given the large number of countries in our analysis, we consider that this issue was addressed. Additionally, our investigation would also benefit from data with a higher frequency, which is unfortunately unavailable for phenomena that we attempted to capture. The collection and computation of such data, be it only for a subset of the variables we investigated, would allow for the application of methodologies that combine different frequencies, such as Mixed-data sampling (MIDAS), a path to consider for future developments. On the other hand, the research can be continued with an analysis of the elements that stimulate the growth of research and development expenses related to energy issues, considering the different specificities of the countries, as a support for stimulating the development of energy consumption from renewable sources.

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