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Determinants of Renewable Energy Development: Evidence from the EU Countries

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Abstract: Sustainable development of the global economy can be achieved with the help of renewable energy (RE). The paper investigates the determinants of RE development in order to boost its adoption. The determinants of RE deployment were analyzed using random-effects GLS regression for the panel data from 27 EU member states in 2011–2020.The results confirm that economic development and high employment in advanced technology manufacturing are drivers of the RE sector, whereas unemployment growth affects RE deployment negatively. Our results show that active political participation and economic freedom promote RE; however, the level of corruption and democracy does not have a statistically significant impact on it. Favorable geographical location was proved to be a determinant of RE development. The hypothesis that plenty of natural resources discourage countries to develop RE was disproved. The major policy implications for RE promotion include the importance of economy deregulation, open market development and educational transformations. Following the results, prospects for further research were outlined.

Keywords: renewable energy; determinants; drivers; factors; GDP per capita; unemployment; democracy; corruption; EU countries

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1. Introduction

Renewable energy (RE) significantly contributes to the transition to the sustainable development of the world economy. Traditional energy resources are harmful to the environment, affect climate change, and impair human health. Oil, natural gas, and other fossil fuels have long been considered acceptable for use due to economic reasons and the lack of alternatives [1]. Technological advances in Industry 3.0 have led to the development of RE equipment. However, in the second half of the XX century, the cost of RE production was high. In recent decades, it has decreased significantly, becoming in many respects competitive with traditional production. For example, the global levelized cost of solar photovoltaic energy declined from 0.289 USD/kWh in 2011 to 0.057 USD/kWh in 2020. Likewise, there has been a significant drop in the cost of offshore and onshore wind energy (Figure 1) [2]. Scientists explain this decrease as being due to technological improvements and the scale effect [3].

Given the negative impact of fossil fuels on the environment, significant fluctuations in their prices, and the lack of relevant resources in many countries around the world (and, as a result, excessive dependence on imports), renewable energy is a quality alternative to traditional energy. In addition, RE technology can increase economic resilience and energy stability via supply diversification [4,5].

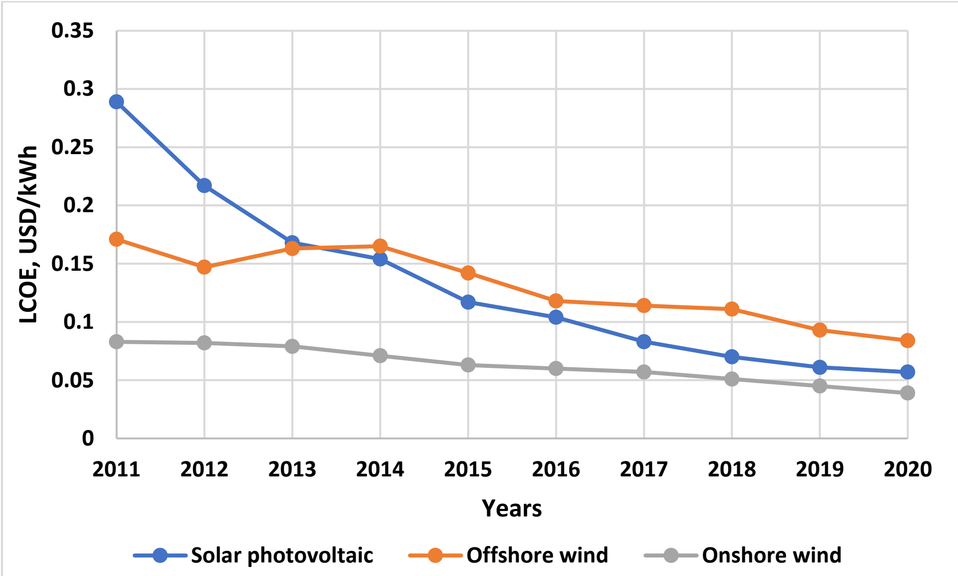

Figure 1. Global levelized cost of solar photovoltaic, offshore, and onshore wind energy in 2011–2020, developed by authors using [2].

The European Union has set a strategic goal to become the first climate-neutral continent by 2050. This can be achieved by a variety of measures, including the significant development of RE. The share of renewables in the overall energy mix increased from 14.55% in 2011 to 22.09% in 2020 (therefore, the EU has achieved its target of 20%). In 2020, the countries with leading positions in RE promotion included Sweden (60.1%), Finland (43.8%), and Latvia (42.1%), whereas Belgium (13.0%), Luxembourg (11.7%), and Malta (10.7%) had the lowest share of energy from renewable sources [6]. The largest share of renewables was in electricity use, whereas the lowest one was in transport use (Figure 2) [7].

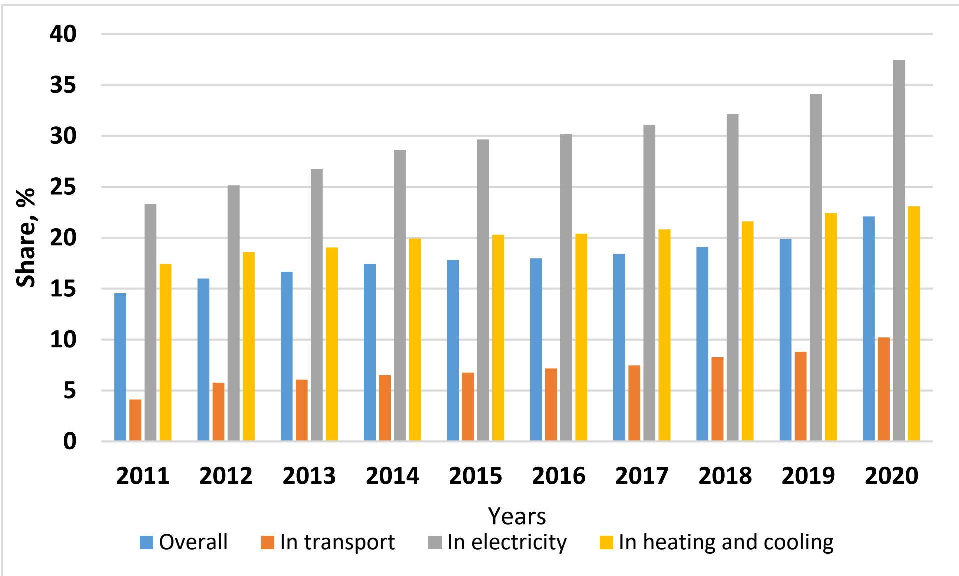

Figure 2. Share of energy from renewable sources in the EU (2011–2020), developed by authors using [6].

However, a complete shift to RE would be complicated without making clear what factors are affecting it. There are a variety of economic, social, technological, environmental, and other determinants of RE development. Understanding them is important for RE promotion.

Many scientists consider economic growth to be a driver of RE [8–12]. The mechanism described in most studies is as follows: more production—more energy (including that from renewable sources). However, this is in contradiction to [13], who emphasizes more complicated links between economic growth and RE. Some scholar state that business freedom and regulatory openness promote investments in RE and, therefore, its development [14,15]. However, others point out that over-liberalization may result in economic overheating and crises, which, in its turn, have a negative impact on RE development [16]. Public awareness about the green economy may promote RE; however, there are no studies on the impact of political participation in general on RE. Therefore, the ambiguous impact of economic, social, political, and institutional factors on RE deployment is a reason for different scientific discussions concerning the main drivers and barriers of RE development.

The main hypotheses tested in this study are as follows:

- A higher level of economic development (expressed by GDP per capita) stimulates the RE sector.
- Higher costs of business start-up procedures (% of GNI per capita) discourage RE development because the necessity to obtain a lot of licenses and permits makes it more difficult for entrepreneurs to launch a new business or project in this sphere.
- Total unemployment (% of the total labor force) has an unknown effect since it is needed to determine whether the unemployed labor force will find a job in the RE sector (especially during an economic recession). Employment in advanced technology manufacturing and knowledge-intensive services (% of total employment) is thought to influence the RE sector positively.
- RE consumption may be promoted by a high level of institutional quality (expressed by such factors as democracy, political participation, low level of corruption, and economic freedom).
- Favorable geographic location (good climate or water access) is positively correlated with RE sector growth, whereas plenty of natural resources (oil and natural gas) is an obstacle to its development.

The rest of the paper is organized in the following way. Section 2 analyzes the relevant scientific publications. Section 3 demonstrates the data and methods used. Section 4 presents the empirical results and related discussion. Section 5 presents the conclusions, policy implications, and future research plans.

2. Literature Review

Identifying contextual clusters of research on the determinants of RE development is necessary. The Scopus Toolkit was used to obtain the proper bibliometric data for analysis. The relevant literature was searched using the following keywords: “renewable energy”, “determinants”, “factors”, and “drivers”. The time frame covered 2017–June 2022.

Bibliometric analysis was carried out using VOSviewer. Taking into account the results of the bibliometric analysis, the following four clusters of scientific research were identified (Figure 3).

- The first (red) cluster (69 items) includes publications concerning the impact of environmental factors on RE development.
- The second (green) cluster (59 items) involves papers on energy and technical issues of renewable usage.
- The third (blue) cluster (56 items) includes papers about economic, social, and institutional factors affecting RE development. They include GDP, national income, economic growth, public policy quality, etc.
- The fourth (yellow) cluster (20 items) includes technological aspects of RE development.

In our research, we concentrated on the third cluster, which includes economic, social, and political factors. Some of these factors (e.g., economic ones) have been discussed by many researchers; however, scientists have still not reached a consensus about the relationship between them.

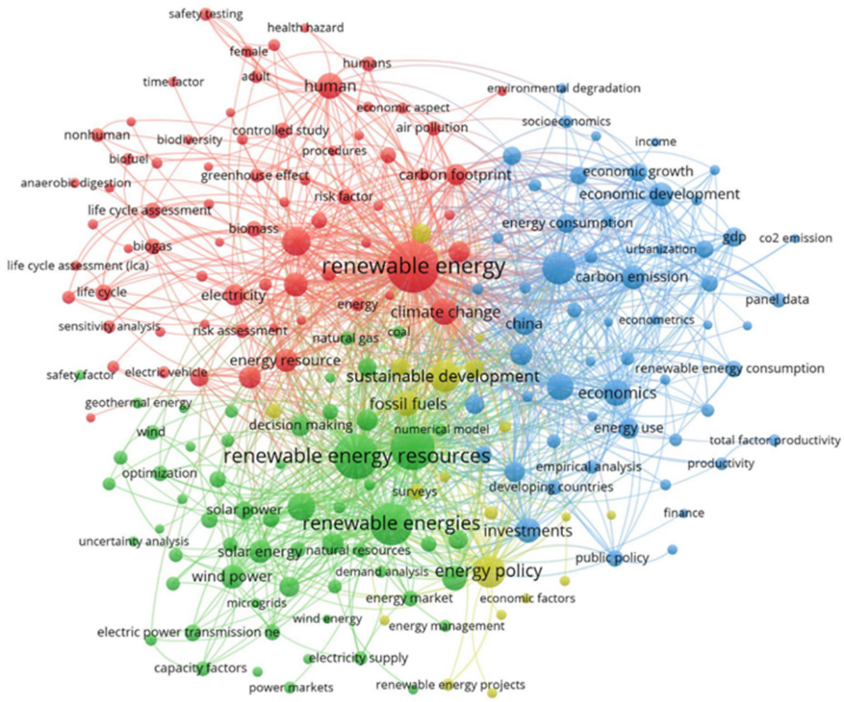

Figure 3. The network map of bibliometric analysis of RE development (created by authors, based on data from Scopus).

Narayan and Doytch explored the nexus between economic growth and RE, using panel data in selected economies from 1971 to 2011. The findings demonstrate that economic growth stimulates non-renewable energy development in countries with a high GDP per capita, whereas there is no such interaction with renewables [8]. This is contradictory to the results obtained by Khan et al. They revealed a bidirectional relationship between GDP growth, FDI, and renewable energy in different countries no matter what their economic development is [13]. Other studies also found a unidirectional or bidirectional relationship between GDP and RE development [9–12].

Salim and Rafiq analyzed macroeconomic determinants of renewable energy in six developing economies. They concluded that the national income has a significant impact on renewable energy both in the short run and long run [17]. The case of China was discussed by [18,19]. Zhao and colleagues considered trade openness as a driver of RE development [18]. Trade openness was also regarded as a stimulator for the RE sector by Omri and Nguyen. Authors also stated that environmental factors (an increase in carbon dioxide emissions) promote RE development. In contrast, the price growth for fossil fuels positively influences the RE sector, but this impact appears not to be strong [20].

The relationship between unemployment and RE deployment is considered to be ambiguous by many scientists. For example, Ohler proved in his study that a higher level of unemployment negatively influences RE deployment. Therefore, job creation promotes RE [21]. This opinion is supported by Delmas and Montes-Sancho [22]. Many scientists consider the impact of RE on unemployment. For example, Rivers utilized the general equilibrium model and proved that a decrease in CO2 emissions by 1% due to renewable energy policy increases the level of unemployment by 0.01–0.03% [23].

Ragosa and Warren proved that a transparent public finance system and regulatory openness positively impact real investments in the RE sector and, as a result, lead to a better performance [14]. Pavlyk also emphasized the positive role of investments for RE development. The author found that a 1% increase in such investments leads on average to a 0.4 percentage points rise in the share of RE [15]. By using technological, economic, and environmental variables for two panels of high- and middle-income countries, Bamati and Raoofi thoroughly examined the determinants of RE generation. The authors have outlined that technological achievements significantly affect renewables in developed economies. In contrast, the deployment of RE sources in emerging economies is not statistically explained considerably by advanced technology exports [24].

A high level of political stability and better institutional quality stimulate the RE sector according to [25–28]. Uzar emphasized that the minimization of corruption leads to better RE deployment, whereas most macroeconomic determinants have no significant impact on it. He has also empirically proved that a high quality of governance promotes RE [29]. Belaid and colleagues obtained similar results. Compliance with the law is an important stimulus for the development of the RE sector, as it encourages companies to produce and use more such energy [30]. Using a panel threshold model, Chen and others have confirmed that democracy is a significant driver of RE deployment [31]. According to the authors, GDP growth and RE consumption are negatively correlated in less democratic states. There are some studies where the RE development in countries with different political regimes is analyzed [32–35]. Some scholars state that an autocratic regime can use its total control and power to pursue RE more effectively and much faster than a democratic regime [32]. However, other scientists point out that an autocratic regime may be oil-reliant, which can discourage it from the RE transition, and only environmental problems may lead to energy-efficient transformations [33,34].

Hvelplund described the experience of Denmark in RE promotion in the context of its political development [35]. The author divided Danish RE development into two main periods: the first one was linked with the introduction of RE technologies, whereas the second was correlated with the market competitiveness of RE. It was proved that democratic institutions and governmental openness are crucial for the second period in order to overcome the possible negative influence of large industrial groups (in this case, the representatives of oil and gas corporations) and political lobbyists. In the author's opinion, successful RE deployment in Denmark is connected with innovative democracy—a political regime in which the interests of all companies (even the smallest ones) are taken into account.

The role of democratic institutions in RE promotion was also discussed by Cadoret and Padovano [36]. They concluded that the rule of law is a stimulator of RE deployment, whereas the impact of oil and natural gas monopolists or oligopolies is destructive. Liberal political parties stimulate RE development more than conservative ones, according to the authors. Overall, high-quality governance is considered to promote RE effectively.

The relationship between RE development and fossil fuel prices was discussed by [37–39]. Having analyzed selected large economies, Apergis and Payne demonstrated that there is a long-run link between RE consumption and traditional energy prices [38]. In general, the interaction between RE and the price of oil and gas is pretty complex. Some researchers have found a unidirectional causal relationship at the extreme quantiles of the distribution, whereas others see no or weak relationship [39]. Bernal et al. investigated the complex mechanism of the impact of fossil fuels on electricity prices [40]. Factors affecting RE consumption in some African countries were discussed in another study [41]. The results of the research demonstrated that there is a negative link between GDP per capita and RE deployment, which is different from the majority of other studies concerning this issue. Similarly, democratic rights and freedom have no significant impact on this sector, according to scientists.

The concept of economic freedom has different interpretations among the scientific community. Nevertheless, personal choice, voluntary exchange, and open markets are key features of the free economy. According to Rapsikevicius and colleagues, the relationship between the level of economic freedom and sustainable development performance can be described with an inverted U-shape graph [16]. Scientists pointed out that more economic freedom promotes sustainable development, but only until the optimal level of economic freedom is achieved. After the turning point, the sustainable development performance begins to drop. Authors explain it in the following way: with too much deregulation and excessive liberty, business processes may be significantly intensified and contribute to economic overheating. Such overheating in the context of renewable energy can also be caused by fiscal overstimulation of this sector (unreasonably excessive reduction in taxes, low import duties, etc.) [42]. A study by Alola and colleagues suggested that economic freedom has a significant impact on RE development in emerging economies, but not in developed ones [43].

There is still little research on the nexus between the abundance of natural resources (especially, oil, natural gas, and coal) and RE development. Other scientists consider the connection between the availability of traditional energy resources and sustainable development in general. They often refer to the theory of resource curse. Oil and gas reliance may be a significant obstacle to sustainability promotion, according to studies [44–46], which may result in worse RE performance.

To conclude, the key points in the literature review are as follows:

- Although there are a variety of publications on economic determinants, scientists have not still reached a consensus about their impact on RE development. Papers have different results concerning these determinants even when analyzing the same regions and/or time frames.
- The role of institutional and political factors is often underestimated in studies. Most existing research concerning this issue is theoretically based and does not use any econometric models.
- There is a lack of research on the relationship between oil and gas reserves and RE deployment. Most studies concentrate only on the nexus between fossil fuel usage and environmental sustainability.

Given the strong relevance of the topic, our research will have a significant contribution by bringing diversity to the analysis of economic determinants and revealing new aspects of the impact of institutional and political factors on RE. To the best of our knowledge, there is no empirical research about the impact of political participation of citizens on RE development. The results of our research can be used in the future for working out the strategy to boost the decarbonization processes and improve RE development at the national level.

3. Methods and Data

In this research, we utilized the data from 27 current EU member states. This choice can be explained by the fact that the EU has a common commercial policy as well as a customs union. Additionally, the member states have a lot in common in terms of environmental and energy policies. These policies are regulated by the Treaty on the Functioning of the European Union, Directive (EU) 2018/2001 on Renewable Energy, the European Green Deal, and other documents [47]. The research employed data for 10 years (from 2011 to 2020). In this study, we used the data from a variety of reliable and trustworthy organizations, including Eurostat [6,7,48], the World Bank [49], the Economist Intelligence Unit [50], Transparency International [51], and the Heritage Foundation [52].

Based on the discussion in Sections 1 and 2, two empirical models were built to evaluate the impact of various factors on RE development. Model 1 and model 2 had the same independent variables, but different dependent variables. In model 1, the share of RE in the total energy consumption is used, while in model 2, renewable energy (electricity) consumption per capita is used as dependent variable.

The authors also used dummy variables to check the last hypothesis concerning the impact of more favorable geographic locations and an abundance of fossil fuels on RE development. In this regard, we also determined countries with more and less favorable geographical locations. The countries with favorable geographical conditions included all EU member states, except Austria, the Czech Republic, Hungary, Luxembourg, and Slovak Republic (they are landlocked and not located in Northern or Southern Europe). Countries with significant oil and gas reserves were chosen in accordance with the data from the U.S. Energy Information Administration [53].

Given the information above, two models can be specified:

$$\text{REt} = \text{f}\ (gdp_t, cb_t, un_t,\ hte_t\ dem_t,\ ppi_t,\ cor_t,\ ef_t,\ res_t,\ cl_t) \tag{1}$$

$$\text{RECt} = \text{f}\ (gdp_t, cb_t, un_t,\ hte_t\ dem_t,\ ppi_t,\ cor_t,\ ef_t,\ res_t,\ cl_t) \tag{2}$$

where:

dependent variables:
RE_t—share of RE in the total energy consumption (%);
REC_t—renewable electricity consumption per capita (in GWh).
independent variables:
gdp_t—GDP per capita (constant 2015 USD);
cb_t—cost of business start-up procedures (% of GNI per capita);
un_t—total unemployment (% of total labor force);
hte_t—employment in high- and medium-high technology manufacturing and knowledge-intensive services (% of total employment);
dem_t—Democracy Index (by the Economist Intelligence Unit, in points (0—totally authoritarian regime, 100—full democracy));
ppi_t—Political Participation Index (by the Economist Intelligence Unit, in points (0—the lowest level of participation, 10—the highest one);
cor_t—Corruption Perception Index (by Transparency International, in points (0—highly corrupt, 100—least corrupt);
ef_t—Economic Freedom Index (by Heritage Foundation, in points (0—totally unfree, 100—absolutely free));
res_t—dummy variable (1—countries with significant oil and natural gas reserves, 0—countries with less or no reserves);
cl_t—dummy variable (1—countries with more favorable geographical conditions (located in the southern or northern part of Europe or water access), 0—countries with less favorable climatic conditions).

4. Results and Discussion

To choose between fixed- and random-effects models, the Hausman specification test was performed. The Hausman specification test demonstrated that for model 2, random-effects GLS regression was more suitable (the null hypothesis of random effects was accepted for the model due to higher efficiency) (Appendix A). An argument in favor of the random effects in model 1 is the necessity to check the binary dummy variables, which is more expedient to do with the random-effects GLS regression. To choose between the random-effects GLS model and Pooled OLS model, the Breusch and Pagan Lagrangian multiplier test for random effects was used. The results demonstrate that random-effects GLS regression was more suitable for both models (Appendix B).

Using STATA 16.0 software for two random-effects models, we obtained the following results (Tables 1 and 2).

GDP per capita had a statistically significant (for p-value < 0.1) positive impact on RE development: when it rose by 1 USD, the share of renewables in the EU member states increased on average by 0.00012%. Similarly, a 1 USD increase in GDP per capita led to a rise in RE consumption per capita by 0.00000005 GWh (=0.05 kWh). Simionescu and colleagues obtained similar results: in their research, an increase in GDP of the EU member states by 1% leads on average to an increase in the share of renewables by 0.001 percentage points [54]. Sadorsky revealed a stronger impact of GDP per capita on RE development: he proved that the 1% growth of GDP per capita leads to an increase in RE consumption per capita by 8% in developed economies [55]. Likewise, a study by Kang et al. found a positive and strong relationship between GDP per capita and RE consumption [56].

Table 1. The random-effects generalized least-squares (GLS) regression of the share of RE (%) for the panel of 27 EU members in 2011–2020.

Random-effects (RE) GLS regr. R-squared: within = 0.4293 between = 0.1332 overall = 0.1422 Correlat.(u_i, X) = 0 (assumed)				Numb. of observations = 270 Numb.of groups = 27 Observ. per group: minimum = 10 averg = 10.0 maximum = 10 Wald chi2(10) = 170.66 Probab. > chi^2 = 0.0000		
RE	Coefic.	Stand.Er.	z(st)	P > ∣z∣	95% Confidence Interval	
gdp	0.0001222	0.0000634	1.93	0.054	-1.99×10^{-6}	0.0002464
cb	−0.2588386	0.0715791	−3.62	0.000	−0.399131	−0.1185463
un	−0.2011204	0.0654852	−3.07	0.002	−0.329469	−0.0727719
hte	0.3737256	0.100829	3.71	0.000	0.1761045	0.5713468
dem	−0.0597961	0.0939434	−0.64	0.524	−0.2439217	0.1243296
ppi	0.0861466	0.0359093	−2.40	0.016	0.0157658	0.1565275
cor	−0.0350046	0.0490036	−0.71	0.475	−0.13105	0.0610408
ef	0.2142435	0.0854286	2.51	0.012	−0.0468066	0.3816805
res	−0.8915666	4.229338	−0.21	0.833	−9.180917	7.397783
cl	10.91367	4.0251	2.71	0.007	3.02462	18.80272
_cons	−0.0081798	9.830657	−1.47	0.141	−33.74438	4.791089

Table 2. The random-effects generalized least-squares (GLS) regression of the renewable electricity consumption per capita (%) for the panel of 27 EU members in 2011–2020.

Random-effects (RE) GLS regr. R-squared: within = 0.4699 between = 0.2140 overall = 0.2181 Correlat.(u_i, X) = 0 (assumed)				Numb. of observations = 270 Numb.of groups = 27 Observ. per group: minimum = 10 averg = 10.0 maximum = 10 Probab. > chi^2 = 0.0000 Wald chi2(10) = 210.29		
REC	Coefic.	Stand.Er.	z(st)	P > ∣z∣	95% Confidence Interval	
gdp	5.20×10^{-8}	7.40×10^{-9}	7.03	0.000	3.75×10^{-8}	6.65×10^{-8}
cb	−0.0000129	7.85×10^{-6}	−1.64	0.100	−0.0000283	2.48×10^{-6}
un	-5.13×10^{-6}	7.35×10^{-6}	−0.70	0.485	−0.0000195	9.27×10^{-6}
hte	0.000044	0.0000115	3.82	0.000	0.0000214	0.0000666
dem	−0.0000138	0.0000104	−1.32	0.187	−0.0000342	6.70×10^{-6}
ppi	0.0000105	3.95×10^{-6}	2.66	0.008	2.78×10^{-6}	0.0000183
cor	1.64×10^{-6}	5.44×10^{-6}	0.30	0.763	-9.02×10^{-6}	0.0000123
ef	0.0000187	9.38×10^{-6}	1.99	0.047	2.81×10^{-7}	0.0000371
res	−0.0002587	0.0007493	−0.35	0.730	−0.0017273	0.0012098
cl	0.0011025	0.0007117	1.55	0.121	−0.0002925	0.0024974
_cons	−0.0025569	0.0012216	−2.09	0.036	−0.0049512	−0.0001626

The cost of business start-up procedures had a negative correlation with a share of renewables in gross final energy consumption (when this cost increased by 1 percentage point, the share of renewables decreased by 0.25%). According to model 2, a rise in the cost of business start-up procedures contributed to a drop in RE consumption, but this impact was statistically insignificant. Private enterprises mostly produced RE in the EU; therefore, the ease of starting and running a business is crucial for RE deployment in general. It is more complicated to launch a new project or to scale up a business when an entrepreneur is limited by the necessity of obtaining numerous licenses, permits, or certificates, spends a lot of money on services of lawyers, etc.

Unemployment had a statistically significant negative impact on RE deployment. When unemployment grew by one p.p., the share of renewable energy dropped by 0.2%, which may be connected with the recessionary processes in the economy. There are some concerns about losing jobs in the traditional energy sector due to RE deployment. However, according to the International Energy Agency, this sector can lose around five million jobs globally, whereas RE can contribute to the creation of about fifteen million jobs (the net gain is around 10 million new workplaces) [57]. Another study emphasizes that most of these new jobs will be dealing with advanced technologies and knowledge-based systems [58]. In this regard, it is crucial to promote STEM education, improve learning standards, and implement lifelong education in order to soften the consequences of possible structural unemployment.

A 1 p.p. growth in employment in advanced technology manufacturing contributed to a rise in the share of renewable energy by 0.37%. Likewise, it contributed to an increase in RE consumption per capita by 0.000044 GWh (=44 kWh). Employment in high-tech industries actualizes the issue of the national production of equipment for renewable energy sources (including solar panels, wind turbines, etc.) SolarWorld and SMA Solar Technology AG (solar panels), Vestas, and Siemens Gamesa (wind turbines) are leading EU companies in the production of such equipment. The world leader in this area is China (in 2020, China produced around 70% of all solar panels and more than 50% of all wind turbines installed globally that year) [59].

The level of democratic development appeared to have no statistically significant impact on RE development. In our opinion, this may be explained by the fact that all countries in the EU are democratic to a greater or less extent (there is no authoritarian or even hybrid regime in the member states; all countries are considered to be democratic (of course, there is differentiation between full and flawed democracy). However, our obtained result is in contradiction with Chen et al., who pointed out that democracy has both direct and indirect impacts on RE consumption [31]. An increase in the Political Participation Index by 1 point resulted in a rise in the share of RE by 0.08% and in the RE consumption per capita by 10.5 kWh. When people are involved in their country's political life, understand the importance of transparent public policy, and constantly interact with their representatives in the national parliament, the green policy is more likely to succeed. Another way to raise awareness about sustainability and RE is participation in non-governmental organizations (NGOs). NGOs contribute a lot to RE promotion. According to the GlobeScan–SustainAbility Survey, experts considered NGOs apparent leaders in achieving SDGs (around 60% of experts shared this opinion) [60]. The level of corruption perception demonstrated no statistically significant effect on RE deployment. This contradicts Uzar [29], who revealed the negative impact of corruption on RE via employing the ARDL-PMG method.

Another determinant of RE development is economic freedom. When there was a rise in the Economic Freedom Index by 1 point, the share of renewables in the EU member states increased by 0.21%. Similarly, the RE consumption per capita increased by 18.7 kWh. This is consistent with Jacqmin [61], who figured out that economic freedom has a significant positive impact on RE investments (and, as a result, on RE performance) in most EU member states.

Favorable geographical location was proved to be a determinant of RE development. If a country is not landlocked or located in the northern or southern part of Europe, it has better prerequisites for RE development. Significant oil or gas reserves were revealed to have no statistically significant impact on RE development in the EU countries. The examples of non-EU members also confirm this. For instance, though Norway has significant oil and gas reserves, it is one of the leading countries in RE promotion (the share of renewables in the total energy mix is 77.4%). However, other scientists emphasize the negative impact of the resource curse on the green transition [44,46].

5. Conclusions

Based on the data from 27 member states of the EU from 2011 to 2020, this paper examined the determinants of RE development. The first tested hypothesis was confirmed: a higher level of economic development (expressed by GDP per capita) does stimulate the RE sector in the EU economies; however, this impact is not strong.

It was proved that higher costs of business start-up procedures discourage RE development, so the government should take up certain deregulation measures and simplify dealing with permits and licenses. The digitalization of public services is a step which can tackle corruption, boost managerial processes, and promote the dematerialization of the economy. To be specific, the government should invest in special software development or website (and/or mobile app) creation, where a variety of public services (business registration or document processing) will be available.

Unemployment growth was revealed to have a statistically significant negative impact on RE development, whereas the more people employed in high- and medium-high technology manufacturing and knowledge-intensive services, the better RE deployment is. Future jobs in RE will require high proficiency and new skills. Therefore, changes in the educational sphere are needed. Policymakers should promote STEM education by improving learning standards (using a competence-based rather than a knowledge-based approach) and investing in educational infrastructure. Governments should constantly monitor the situation and tendencies in the labor market to adapt the educational system to these needs. Another important task for policymakers is to promote lifelong education in cooperation with universities and/or local authorities. All educational transformations should include environmental awareness.

The hypothesis about the positive impact of institutional quality on RE development has been only partially confirmed. Given all countries in the EU are democratic to a greater or less extent, the level of democracy does not have a significant impact on RE development. However, the level of participation in political processes positively influences RE, so it is crucial that policymakers create a favorable environment for non-governmental organizations by establishing a reliable legislative framework and its implementation. In turn, civil society should actively promote their initiatives, for example, sustainability and the green economy. Though corruption is a negative social phenomenon, its link with RE development is still unclear (according to our results, its impact is negative but statistically insignificant). It was proved that free economies have better RE performance, so decisionmakers should protect individuals and companies from illegal actions, create a secure fiscal environment, and develop open markets. Additionally, governments should develop green financial markets, raise awareness about such financial instruments, and enhance their integration into the traditional markets.

Significant oil or gas reserves are not an obstacle for countries in developing their RE sector. Additionally, the state's revenue from oil and gas industries can be used for RE promotion and a gradual reduction in traditional energy resources. The hypothesis that countries with favorable geographic locations are likely to have better performance in RE sector was proved. However, this does not mean that other nations should refrain from the development of RE. The current level of technology development allows for increasing the volume of energy production even in adverse climatic or weather conditions.

Our key finding is that RE promotion requires strategic decisions and their step-by-step implementation, including ensuring a high quality of public governance, political participation of citizens, economic deregulation and business freedom, educational reforms, etc. To increase the positive impact on the environment, these actions should be accompanied by economic decarbonization strategies (effective system of CO_2 emissions monitoring, green infrastructure development, smart industry formation, etc.).

Further research should concentrate on the extension of the model by adding other important variables (e.g., economic (gross fixed capital formation, fossil fuel prices), social (the level of poverty and income distribution), and institutional (press and media freedom)), using this or other econometric approaches and covering larger time periods and number of countries. Future investigations may also focus on results estimation after categorizing countries according to their weather and geographical conditions.

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Appendix A

Table A1. Hausman specification test for model 1.

—- Coefficients —-				
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	fe	re	Difference	S.E.
gdp	0.0002557	0.0001222	0.0001335	0.0000289
cb	−0.2326486	−0.2588386	0.0261901	.
un	−0.1147809	−0.2011204	0.0863396	0.0145427
the	0.5414455	0.3737256	0.1677199	0.034857
dem	0.0074234	−0.0597961	0.0672194	0.009444
ppi	0.0606193	0.0861466	−0.0255273	.
cor	−0.0103681	−0.0350046	0.0246365	0.0018912
ef	0.2060948	0.2142435	−0.0081488	.

b = consistent under Ho and Ha; obtained from xtreg; B = inconsistent under Ha, efficient under Ho; obtained from xtreg; Test: Ho: difference in coefficients not systematic; chi2(8) = (b-B)′[(V_b-V_B)^(-1)](b-B) = 79.91; Prob > chi2 = 0.0000; (V_b-V_B is not positive definite).

Table A2. Hausman specification test for model 2.

—- Coefficients —-				
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	fe	re	Difference	S.E.
gdp	5.70×10^{-8}	5.20×10^{-8}	4.93×10^{-9}	2.35×10^{-9}
cb	−0.0000118	−0.0000129	1.06×10^{-6}	.
un	-2.32×10^{-6}	-5.13×10^{-6}	2.81×10^{-6}	1.38×10^{-6}
the	0.0000477	0.000044	3.71×10^{-6}	2.95×10^{-6}
dem	−0.0000136	−0.0000138	2.15×10^{-7}	1.29×10^{-6}
ppi	9.50×10^{-6}	0.0000105	-1.02×10^{-6}	.
cor	1.75×10^{-6}	1.64×10^{-6}	1.18×10^{-7}	5.72×10^{-7}
ef	0.0000191	0.0000187	4.71×10^{-7}	.

b = consistent under Ho and Ha; obtained from xtreg; B = inconsistent under Ha, efficient under Ho; obtained from xtreg; Test: Ho: difference in coefficients not systematic; chi2(8) = (b-B)′[(V_b-V_B)^(-1)](b-B) = 11.93; Prob > chi2 = 0.1544; (V_b-V_B is not positive definite).

Appendix B

Table A3. Breusch and Pagan Lagrangian multiplier test for random effect for model 1.

Breusch and Pagan Lagrangian multiplier test for random effects re[id,t] = Xb + u[id] + e[id,t] Estimated results:		
	Var	sd = sqrt(Var)
re	133.9228	11.5725
e	3.671963	1.916237
u	89.35588	9.452824

Test: Var(u) = 0; chibar2(01) = 862.23; Prob > chibar2 = 0.0000.

Table A4. Breusch and Pagan Lagrangian multiplier test for random effect for model 2.

Breusch and Pagan Lagrangian multiplier test for random effects rec[id,t] = Xb + u[id] + e[id,t] Estimated results:		
	Var	sd = sqrt(Var)
rec	3.97×10^{-6}	0.0019916
e	4.56×10^{-8}	0.0002136
u	2.96×10^{-6}	0.0017202

Test: Var(u) = 0; chibar2(01) = 979.55; Prob > chibar2 = 0.0000.

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