The role of party polarization in renewable energy consumption: fresh evidence across the EU countries

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Abstract

The essential role of renewable energy in mitigating the negative consequences of climate change has led to a growing body of literature that has examined the determinants of renewable energy consumption. Most of the existing studies focused on the macroeconomic, environmental, institutional, and energy-related determinants of renewable energy consumption and neglected the potential role of partisan polarization. The adverse effects of party polarization have been well documented by the literature, but the impact of party polarization on renewable energy consumption has not been examined. To fill this existing gap, this study explicitly explores the association between renewable energy consumption and partisan polarization across 25 European Union countries, spanning the period 2003-2017. The findings document that party polarization is negatively associated with renewable energy consumption after accounting for an extensive set of macroeconomic, environmental, institutional, and energy-related determinants and the use of a different set of estimation methodologies. The paper's findings show another adverse effect of party polarization by demonstrating its negative impact on renewable energy consumption.

Keywords: Renewable energy; Politics; Polarization; Institutions; Energy Policy

JEL Classification: D72; D73; Q28; P48

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1. Introduction

The increased economic activities have been placing a greater extent of pressure on the environment. Energy consumption has been one of the main contributors to the increased greenhouse gas emissions, and hence to the global warming (Intergovernmental Panel on Climate Change, 2014), as the majority of the world's energy consumption has been from fossil fuels (International Energy Agency, 2019). The rapid increase in greenhouse gas emissions and environmental degradation, as well as concerns over energy security make it an essential international agenda to increase renewable energy consumption. Therefore, it has become vital to understand the determinants of renewable energy consumption, which has led to a growing body of literature examining the determinants of the renewable energy consumption (see, e.g., Aguirre and Ibikunle, 2014; Bourcet (2020) for a detailed review of the empirical determinants of renewable energy consumption).

Most of the existing studies focus on macroeconomic, environmental, institutional, and energy-related determinants of renewable energy consumption. Some of the macroeconomic factors that have been found to be important include economic growth, trade openness, financial openness, and foreign direct investment. Economic growth has been considered one of the drivers of the increased use of renewable energy sources as more resources could be moved to investment in capital intensive renewable energy projects (Sadorsky, 2009a; Sadorsky, 2009b; Apergis and Payne, 2010; Menegaki, 2011; Salim and Rafiq, 2012; Chang et al., 2015; Omri et al., 2015a, b; Kahia et al., 2016; Rafindadi and Ozturk, 2017; Koçak and Şarkgüneşi, 2017; Pereira da Silva et al., 2018, among many others). Furthermore, trade openness is also considered to be a good proxy to measure the level of countries' engagement with other countries through the movement of goods and services, which would also enable countries to access renewable energy technologies and increase the use of renewable energy (Omri and Nguyen, 2014; Brini et al., 2017; among others). In the same lines, foreign direct investment (FDI) is considered to be a source of innovation, while it substantially promotes energy efficiency (Abdouli and Hammami, 2017) and the use of renewable energy consumption (Doytch and Narayan, 2016). Finally, financial development is found to be a significant driver of renewable energy (Brunnschweiler, 2010; Lin et al., 2016; Hassine and Harrathi, 2017; Rasoulinezhad and Saboori, 2018).

Another strand of the literature has extensively used energy- and environment-related factors as part of their analysis. As the energy consumption from fossil fuels, such as coal, crude oil, and natural gas are the major determinants of CO2 emissions, the existing literature also considers the amount of energy consumption from fossil fuels and their respective prices as determinants of renewable energy since these energy sources are considered as substitutes of renewable energy (Apergis and Payne, 2014; Shearer et al., 2014; Ackah and Kizys, 2015; Omri et al., 2015a, b). Another important proxy considered to be a driver of renewable energy consumption is CO2 emissions (Marques et al., 2011; Bengoche and Faet, 2012; Salim and Rafiq, 2012; Omri and Nguyen, 2014; Nguyen and Kakinaka, 2019, among many others). The increased importance of reducing CO2 emissions to combat global climate change encourages countries to use more renewable energies and promote environmental protection, while countries that found to emit more are shown to increase the use of renewable energy sources. Finally, another strand of the literature also highlights that countries have started to invest more in renewable energy sources to decrease their energy dependence, as well as their energy security (Marques et al., 2011).

The quality of institutions has been also found to be vital in promoting the use of renewable energy (Brunnschweiler, 2010; Pfeiffer and Mulder, 2013; Wirth, 2014; Cifor et al., 2015; Fankhauser et al., 2015; Chang and Wang, 2017; Bhattacharya et al., 2017; Mertzanis, 2017; Bellakhal et al., 2019; Uzar, 2020). For instance, Fredriksson and Svensson (2003) argue that political instability and corruption reduce the stringency of environmental regulations. Similarly, Pfeiffer and Mulder (2013) find that the renewable energy technology diffusion increases with the quality of democratic institutions, and Fankhauser et al. (2015) also document that the number of legislation related to climate change is relatively higher in countries with better institutional quality. Overall, this stream of literature finds that the countries that are less corrupt, with a better rule of law and regulations and governance, and with lower levels of political instability, tend to increase renewable energy consumption. In a related area of research, it has been found that the ideological position of the governments has been also found to be significantly affecting the consumption of renewable energy. It has been highlighted that the left-wing parties have had a higher tendency to consider environmental demands from society and regulate the energy markets and promote the consumption of renewable energy more than right-wing parties (Chang and Berdiev, 2011; Biresselioglu and Karaibrahimoglu, 2012 Cadoret and Padovano, 2016). Even though this stream of literature considers the ideological stance of the governments for renewable energy consumption, these studies do not account for or control for the role of party polarization. This paper aims to fill this research gap by examining the explicit role of party polarization in the consumption levels of renewable energy.

More specifically, the reason we argue that partisan polarization matters for renewable energy consumption is that the decision-making of the parliament or the government would be harder if the parliament or government had consisted of ideologically polarized parties. It has been well-documented that a polarized political system increases the relative price of investments (Azzimotti, 2011), lowers corporate investment levels (Azzimotti, 2018), and generates higher political uncertainty (Azzimotti and Talbert, 2014; Baker et al., 2014) and government debt (Alesina and Tabellini, 1990; Persson and Tabellini, 2004; Crivelli et al., 2016; Yared, 2019), while it leads to different views on the same reality, which then generates policy divergences (Alesina et al., 2020). For instance, Bolsen et al. (2015) examine the beliefs of the public, scientists, and policy advisors on global warming and find that ideological polarization among the three groups plays an important role, while the reconciliation among these groups is harder along with the polarization. Farrell (2016) suggests that polarization is an effective strategy for creating controversy and delaying policy progress, especially around environmental issues. Based on the existing literature, we expect that the countries that are politically polarized consume relatively lower levels of renewable energy due to increased political uncertainty and delay environmental regulations. To test this hypothesis, we explicitly explore the role of partisan polarization in renewable energy consumption by examining the link between renewable energy consumption and party polarization across 25 European Union (EU) countries over the period 2003-2017 after accounting for an extensive list of other factors considered to be important determinants of renewable energy consumption.

The EU is a promising case for the analysis of this paper for two reasons. Firstly, the EU has a directive that sets a new binding renewable energy target for the EU for 2030 of at least 32% to meet the commitments to the Paris Agreement. As part of this package, each member state agreed on national plans to address energy efficiency, renewables, and greenhouse gas emissions reductions. Even though each country has specific commitments, it is important to examine the factors contributing to the promotion to renewable energy to identify factors that could contribute to the achievement of these goals. Secondly, there has been a rise in support of parties opposing to EU and the rise of populist parties in the EU (e.g., Hobolt, 2016; Dijkstra et al., 2020). Clearly, meeting the EU renewable energy goals also requires political commitment at the national level and examining the role of the recent rise in political polarization in the EU on renewable energy consumption would be an important contribution to the literature. Even though there has been previous analysis on the determinants of the renewable energy consumption in the EU (see e.g., Akadiri et al., 2019; Berk et al., 2020; Papież et al., 2018), the existing literature has not examined the role of political polarization in achieving the renewable energy goals set.

The remainder of the paper is organized as follows. Section 2 provides the estimation methodology, while Section 3 presents the details of the data used and how the party polarization is measured. Section 4 provides the estimation results, while a set of robustness checks is also reported in Section 5. Finally, Section 6 concludes.

2. Methodology

Given that the goal of this empirical work is to explore the role of political polarization in the consumption of renewable energy, the model specification (in logs) is indicated below in Equation (1):

$$\log(ren_{it}) = a_{1i} + a_{2t} + b_1 \log(ren_{i(t-1)}) + b_2 \log(polar_{it}) + c \log(X'_{it}) + e_{it} \quad (1)$$

where i = country, t = period (year); a_{1i} denotes country fixed effects and a_{2t} denotes time fixed effects, while the disturbances e_{it} are uncorrelated. ren denotes renewable energy consumption and polar is the primary variable associated with the political polarization measure. Finally, X’ is a vector of control variables that affect the consumption of renewable energy and defined in the data section. To avoid the presence of potential endogeneity, the empirical analysis makes use of the general method of moments (GMM) method introduced by Arellano and Bover (1995) and Blundell and Bond (1998). There are various advantages of using the system GMM as it addresses the issue of dynamic bias and also allows one to account for the potential endogeneity of the regressors, which way rise due to measurement error, omitted variable bias or reverse causality. Another preferred option for the system GMM is when the application consists of relatively large number of countries and limited time periods, which is the case for the empirical application of this paper. The system GMM method has been extensively used by the recent literature to account for these issues while examining the determinants of the renewable energy consumption (see e.g., Abban and Hasan, 2021; Asongu and Odhiambo, 2021; Berk et al., 2020; Qamruzzaman and Jianguo, 2020, among many others). Henceforth, to account for the above-mentioned empirical problems, one of the employed methodologies in this paper is the system GMM.

The presence of endogeneity could potentially be explained by reverse causality between polarization and renewable energy among other regressors. More specifically, opposition to the adoption of renewable energy policies has emerged globally on the grounds that such policies pose a threat to jobs in fossil-fuel industrial sectors, the high financing cost of renewable energy projects, and the associated technical problems of managing electricity grids based on non-fossil energy sources (Rootes et al. 2012; Fielding et al., 2012; Young and Coutinho, 2013; Carter and Clements, 2015). This reverse causality hypothesis touches two primary strands in the literature: First, the renewable energy policy-adoption literature, which is associated with the control of a legislature by a left/progressive party and to general measures of political preference for left/progressive ideology or parties (Matisoff and Edwards, 2014), the importance of environmentalists and the strength of the fossil fuel sector (Coley and Hess, 2012), and the role of institutional factors, documenting diffusion effects (Vasseur, 2014). The second strand is related to the policy-adoption hypothesis which provides information on the causes of successful adoption; this describes an institutional arrangement that is intended to provide checks and balances on political power (Binder, 2015). Given the above discussion, the GMM equation yields:

$$\Delta\log(ren_{it}) = a_{1i} + a_{2t} + \sum_{k=1}^{p_1} b_{1k}\Delta\log(ren_{i(t-k)}) + \sum_{k=0}^{p_2} b_{2k}\,\Delta\log(polar_{it-k}) + c\sum_{k=0}^{p_3} c_{ik}\Delta\log(X'_{it-k}) + e_{it} \qquad (1')$$

where Δ denotes first differences.

In addition, the empirical analysis performs Granger causality between renewable energy and polarization by considering the panel causality test by Dumitrescu and Hurlin (2012); this method considers two dimensions of heterogeneity, that of the regression model and that of the causality relationships. The method assumes the absence of cross-sectional dependency. The method considers an equation modelling like that described in Equation (1)’ above. Then, it assumes that ren_{it} follows an autoregressive distributed lag, ARDL(p_1, p_2, p_3) process; more generally, ren_{it} can be considered as one of the equations of a joint VAR model for (ren_{it}, $polar_{it}$, X_{it}). The null hypothesis that our series, say $polar_{it}$ does not Granger-cause (linearly) the series ren_{it} can be formulated as a set of linear restrictions on the coefficients b_2’s and c’s in Eq. (1’):

H_0: $b_{2ik} = 0$, for all i and k

and

H_0: $c_{ik} = 0$, for all i and k

against the alternative:

H_1: $b_{2ik} \neq 0$ for some i and k

and

H_1: $c_{ik} \neq 0$ for some i and k

For the Dumitrescu-Hurlin test, the Wald statistic is defined as:

$Z_{N,T} = \sqrt{N/2K}\,(W_{N,T} - K)$

where K is the number of lags in the corresponding VAR model, and:

$$W_{N,T} = 1/N \sum_{i=1}^{N} W_{i,T}$$

where $W_{i\,T}$ denotes the individual Wald statistical values for cross-section units.

3. Data

The analysis employs annual data from 25 European Union (EU) countries (the country list is offered in the Appendix), spanning the period 2003-2017. In this section, we provide the details on how party polarization is measured, and the measure used for renewable energy consumption, along with the other control variables included in the model under consideration.

The dependent variable is the total renewable energy consumption measured in millions of kwt. In terms of the primary independent variables, a popular proxy used is the political fractionalization based on the Herfindahl-Hirschman type of index (Alesina et al., 2003). The index measures the probability that two representatives picked at random from the parties in the legislature will be of different parties (Del Monte and Papagni, 2007; Dalton, 2008; Funke et al., 2016). The political fractionalization (PF) of a country *j* is calculated as follows:

$$PF_j = 1 - \sum_{i=1}^{n} V_{ij}^2 \quad (1)$$

where V_{ij} is the vote share of political party *i* in country *j*. The political fractionalization index ranges between 0 and 1, where higher values present more fractionalized political competition.

Even though the political fractionalization index provides how fragmented the political system is, this measure does not capture how polarized the political systems is, as it does not differentiate for the ideological positions of the parties involved. It is possible to observe high levels of polarization in less fragmented party systems, or lower levels of political polarization within a more fractionalized system (Pelizzo and Babones (2007). Therefore, the literature has also been using different political polarization measures by taking explicitly into account the ideological position of the parties. Most of the cross-country analyses on political polarization have been using political factors coming from the Database of Political Institutions, first constructed by Beck et al. (2001), and updated by Cruz et al. (2018). The database of political institutions provides the ideological position of major parties based on their economic attitudes where political positions coded as one, two and three if a party is considered to stand in the left, center and right spectrum. Using these data set, Brown et al. (2011) obtain the political polarization measure by estimating the greatest ideological distance between the four major parties and coding their polarization measure as one if elected bodies only feature center-left or center-right representation across the largest parties, and polarization coded two in states featuring a large left- and right-wing presence across elected officials. A similar measure is obtained by Testa (2010), who has used the ideological distance between governing and opposition parties.

In a similar context, Potrafke (2009, 2010) uses the index of governments' ideological positions, first introduced by Budge et al. (1993) and updated by

Woldendorp et al. (1998, 2000). This index places the cabinet on a left-right scale with values between 1 and 5, where a value of one is assigned if the share of governing right-wing parties, in terms of seats in the cabinet and in parliament, is larger than 2/3, and 2 if it is between 1/3 and 2/3; the index is 3, if the share of centre parties is 50%, or if the left- and right-wing parties form a coalition government that is not dominated by one side or the other, and the index is symmetric and takes the values of 4 and 5, if the leftwing parties dominate.

Polarization measures used by the literature (Potrafke, 2009; Potrafke, 2010; Brown et al., 2011; Testa, 2012) only differentiate the parties based on whether they are positioned in the left, centre or right political spectrum, and does not differentiate how far left or right a political party is positioned. However, Döring and Manow (2019) database offers a wider range of left-right scale of political parties, ranging between 0 and 10 with the use of party expert surveys, with 0 representing extreme left and 10 extreme right. Assessing the ideological stance of the political parties based on the experts' survey, is commonly used and accepted as the most reliable measure for party positions (Benoit and Laver, 2006; Bakker et al., 2015). With the use of Döring and Manow (2019) database, we calculate the political polarization (PP) based on the calculations of Dalton (2008) and Wang (2014) as follows:

$$PP_j = \sum_{i=1}^{n} V_{ij} \times \left(\frac{LRS_i - AIP_j}{5}\right)^2 \qquad (2)$$

where V_{ij} is the vote share of the political party *i* in country *j*, LRS_i is the left-right scale position of party *i*, and AIP is the weighted average of the ideological position of country *j* (which is calculated by the weighted average of the political positions of parties in a given country). The political polarization index ranges between 0 and 10, where higher scores represent more of an ideologically polarized political system. Beyond the political polarization index, we also use the ideological position difference among the parties that govern (ranging from 0 to 10, with 0 if there is a majority government), Gov_ideo_dif hereafter, the highest ideological difference among the four major parties (ranging from 0 to 10), Major4_ideo_dif hereafter, and the ideological difference between the two major parties (ranging from 0 to 10), Major2_ideo_dif hereafter, with higher measures suggesting higher political polarization.

The analysis also controls for the institutional quality differences among countries by controlling for various institutional quality proxies and which may also affect the consumption of renewable energy (Wirth, 2014; Cifor et al., 2015; Chang and Wang, 2017; Bhattacharya et al., 2017; Mertzanis, 2018). More specifically, we control for five governance measures obtained from World Governance Indicators (WGI): Control of corruption (WGI-CC) (ranging from -2.5 to +2.5), Voice and accountability (WGI-VA) (ranging from -2.5 to +2.5), Political Stability (WGI-PS) (ranging from -2.5 to +2.5), Government effectiveness (WGI-GE) (ranging from -2.5 to +2.5), and Regulatory Quality (WGI-RQ) (ranging from -2.5 to +2.5) indexes; these measures are sourced from the World Governance Indicators database, with higher values indicating better governance.

Other control variables include socioeconomic variables that can also be identified to be important drivers of renewable energy consumption. In particular, we control for total population (POP) (Shabbir et al., 2014; Salim and Shafiei, 2014), carbon emissions (in millions of metrics) (Sadorsky, 2009; Bengoche and Faet, 2012), GDP per capita at 2010 dollar prices (Apergis and Payne, 2010; Menegaki, 2011), fossil energy consumption, such as oil and natural gas consumption measured in millions of kwt (Shearer et al., 2014), oil and natural gas prices (WTI prices: US dollar per barrel, average German import prices: US dollars per million Btu, respectively) (Ackah and Kizys, 2015; Omri et al., 2015a, b), foreign direct investments as percentage of GDP, defined as net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor: the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital (FDI) (Doytch and Narayan, 2016; Abdouli and Hammami, 2017), and financial development (FIN-defined as the ratio of bank credit to GDP) (Lin et al., 2016; Hassine and Harrathi, 2017; Rasoulinezhad and Saboori, 2018). The data were sourced from the World Development Indicators database, as well as the Thomson Reuters (Datastream) database. Table 1 presents certain summary statistics.

Table 1. Summary statistics

Variables	Mean	SD	Min	Max

Renewable energy	177,994.6	307,839.2	-47,935.6	1,476,435.3
Polarization index	3.989	0.875	1.508	6.655
Fractionalization index	0.760	0.084	0.506	0.898
Gov_ideo_dif	2.087	1.593	0.000	5.905
Major4_ideo_dif	4.892	1.305	1.925	8.311
Major2_ideo_dif	3.243	1.472	0.132	7.632
WGI-CC	1.166	0.726	-0.189	2.469
WGI-VA	1.200	0.269	0.366	1.801
WGI-PS	0.805	0.393	-0.474	1.688
WGI-GE	1.255	0.507	0.198	2.354
WGI-RQ	1.284	0.378	0.148	2.047
GDP (pc)	35,086.9	20,561.8	8,893.9	111,968.4
Population	18,836,760.5	23,813,856.5	398,582.0	82,657,002.0
FDI (% GDP)	15.023	45.785	-58.323	451.639
Financial develop. (% GDP)	96.694	45.882	0.186	255.310
Oil prices	69.260	20.913	33.784	109.340
Natural gas prices	7.840	2.237	4.400	12.676
Oil consumption	331,102.9	413,404.5	14,977.5	1,621,727.9
Natural gas consumption	202,379.7	292,798.1	0.000	1,097,772.8
Carbon emissions (total)	137.135	183.147	1.354	820.732
No. of obs.	375			

SD = standard deviation, pc = per capita, WGI-CC = control of corruption, WGI-VA = voice and accountability, WGI-PS = political stability, WGI-GE = government effectiveness, WGI-RQ = regulatory quality.

4. Empirical analysis

First, the empirical analysis examines the degree of residual cross-sectional dependence. To this end, this part of the analysis uses the cross-sectional dependence (CD) statistic by Pesaran (2004). The results, reported in Table 2, reject the null hypothesis of cross-section independence.

Table 2. Cross dependence tests

Variables	Test values	p-values
Renewable energy	28.95***	0.00
Polarization	29.53***	0.00
Fractionalization	32.08***	0.00
Gov_ideo_dif	36.71***	0.00
Major4_ideo_dif	29.84***	0.00
Major2_ideo_dif	27.69***	0.00
WGI-CC	31.84***	0.00
WGI-VA	36.58***	0.00
WGI-PS	29.06***	0.00
WGI-GE	32.41***	0.00
WGI-RQ	36.77***	0.00
GDP (pc)	34.56***	0.00
FDI inflows	31.09***	0.00
Population	28.04***	0.00
Financial development	35.62***	0.00
Oil consumption	37.81***	0.00
Natural gas consumption	28.66***	0.00
Carbon emissions (total)	31.08***	0.00

Notes: The test examines the null hypothesis of cross-sectional independence, pc = per capita, WGI-CC = control of corruption, WGI-VA = voice and accountability, WGI-PS = political stability, WGI-GE = government effectiveness, WGI-RQ = regulatory quality. ***: $p \leq 0.01$.

Next, a second-generation panel unit root test is employed to investigate integration properties of the variables under consideration. The Pesaran (2007) panel unit root test examines the null hypothesis of a unit root. The results, reported in Table 3, provide solid evidence in support of a unit root across all variables.

Table 3. Panel unit root tests

H_0 : Contains a unit root	
	CIPS

Variables	Levels	1st Differences
Renewable energy consumption	-1.139	-6.195***
Polarization	-1.139	-6.271***
Fractionalization	-1.144	-6.265***
Gov_ideo_dif	-1.214	-6.139***
Major4_ideo_dif	-1.108	-6.214***
Major2_ideo_dif	-1.136	-6.638***
WGI-CC	-1.181	-6.127***
WGI-VA	-1.274	-6.259***
WGI-PS	-1.138	-6.246***
WGI-GE	-1.142	-6.105***
WGI-RQ	-1.246	-6.273***
GDP (pc)	-1.125	-6.347***
Population	-1.136	-6.384***
Financial development	-1.231	-5.988***
FDI	-1.247	-6.341***
Oil consumption	-1.185	-6.289***
Natural gas consumption	-1.149	-6.559***
Carbon emissions (total)	-1.204	-6.492***

Notes: A constant is included in the Pesaran (2007) tests. The results are reported under the null hypothesis of stationarity. pc = per capita, WGI-CC = control of corruption, WGI-VA = voice and accountability, WGI-PS = political stability, WGI-GE = government effectiveness, WGI-RQ = regulatory quality, critical values for the Pesaran (2007) test: -2.40 at 1%, -2.22 at 5%, and -2.14 at 10%. The results are reported at lag = 2, ***: p≤0.01.

Table 4 reports the empirical results obtained with the system GMM method, with columns indicating certain specifications. Significant lags (where possible) have been determined through the Akaike criterion. Columns (1) through (5) display the estimates when different polarization measures and institutional quality measures are used in different columns. More specifically, Column (1) shows the results when polarization is measured through the Polarization variable, Column (2) when polarization is measured through the Fractionalization variable, Column (3) when polarization is proxied as Ideology difference between parties that govern, Column (4) when polarization is depicted through the variable of Highest ideological difference among 4 major parties, and Column (5) when polarization is proxied as Ideological difference among 2 major parties. All five specifications contain the remaining control variables. The results remain consistently similar across different measures of polarization and institutional quality measures. The relevant diagnostics are also reported in Table 4. In all cases, we test for the serial correlation in the error term by using the Arellano-Bond test where the AR (2) test results suggest that the null hypothesis is rejected, indicating no second-order serial correlation. Furthermore, difference-in-Hansen is the test of validity of GMM instruments and the test of overidentification is based on the Hansen J statistic. The idea is to estimate the GMM system of equations is where the instruments used in the equations are lagged first-differences of the series. This allows for the levels of the control variables (as well as the dependent variable) to be correlated with the unobserved country-specific effects while permitting suitably lagged first-differences of these variables to be used as instruments in the equations. For the empirical ends of the estimates in Table 4, we have used lagged differences of the dependent variable as instruments for the equation in levels in addition to lagged levels of it as instruments for equations in first differences. This approach adopted because although there may be a correlation between the levels of the control variables and the country-specific effect in the level equation, there is no correlation between the differences of these variables and the country-specific effect. To be more specific, the estimations used one lag from each control variable, with the number of total instruments used reported in Table 4. The null hypothesis is that the instruments are valid (i.e., uncorrelated with the error term), and that the exclusions restrictions are valid (i.e., the instruments are correctly excluded from the second-stage equation), suggesting that the use of the system GMM is well defined.

Overall, the estimates clearly document in favour of a negative and statistically association between the polarization and renewable energy consumption, implying that stronger levels of polarization are associated with lower renewable energy consumption. Overall, a percentage increase in the polarization measures (i.e., polarization, fractionalization ideological position difference among the parties that govern, highest ideological difference among the four major parties and the ideological difference between the two major parties) decreases the renewable energy consumption by roughly 0.01%. In terms of the remaining determinants of renewable energy consumption, the estimate of the coefficient of the lagged dependent variable is between 0 and 1, suggesting that the growth in renewable energy consumption is faster in countries/periods with a lower initial level of renewable energy consumption (see e.g., Berk et al., 2020 for similar finding for the EU countries). The estimates for the five institutional quality variables (i.e., Control of Corruption, Voice and Accountability, Political Stability, Government Effectiveness, and Regulatory Quality) exert a positive and statistically significant impact on renewable energy consumption. In other words, countries with better institutional quality tend to use higher levels of renewable energy consumption (e.g., Bellakhal et al., 2019; Uzar, 2020). On the other hand, the countries with higher population, higher economic and financial development tend to use more of renewable energy consumption. Similarly, FDI encourages the use of renewable energy consumption (Doytch and Narayan, 2016). Finally, we also find that oil and natural gas prices exert a positive effect on the consumption of renewable energy, while higher levels of two types of fossil energy consumption have a negative impact on the consumption of renewable energy. Finally, carbon emissions exert a positive effect on renewable energy consumption. Overall, the estimates are in accordance with the majority of findings in the relevant literature.

Table 4. Renewable energy consumption and polarization: GMM estimates

Variables	(1)	(2)	(3)	(4)	(5)
Renewable energy(-1)	0.0414***	0.0389***	0.0455***	0.0436***	0.0398***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Polarization	-0.0096***				
	[0.00]				
Fractionalization		-0.0097***			
		[0.00]			
Gov_ideo_dif			-0.0116***		
			[0.00]		
Major4_ideo_dif				-0.0107***	
				[0.00]	
Major2_ideo_dif					-0.0119***
					[0.00]
WGI-CC	0.0074***				
	[0.00]				
WGI-VA		0.0059***			
		[0.01]			
WGI-PS			0.0063***		
			[0.00]		

WGI-GE				0.0029^{*}	
				[0.07]	
WGI-RQ					0.0048^{**}
					[0.03]
GDP (pc)	0.0068^{***}	0.0076^{***}	0.0064^{***}	0.0067^{***}	0.0063^{***}
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Population	0.0060^{***}	0.0062^{***}	0.0058^{***}	0.0065^{***}	0.0059^{***}
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Financial development	0.0096^{***}	0.0098^{***}	0.0089^{***}	0.0098^{***}	0.0087^{***}
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
FDI	0.0162^{***}	0.0159^{***}	0.0156^{***}	0.0158^{***}	0.0144^{***}
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
FDI(-1)	0.0099^{***}	0.0114^{***}	0.0105^{***}	0.0097^{***}	0.0101^{***}
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Oil prices	0.0124^{***}	0.0128^{***}	0.0125^{***}	0.0119^{***}	0.0128^{***}
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Oil prices(-1)	0.0064^{***}	0.0067^{***}	0.0064^{***}	0.0071^{***}	0.0065^{***}
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Natural gas prices	0.0059^{***}	0.0065^{***}	0.0058^{***}	0.0054^{***}	0.0051^{***}
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Oil consumption	-0.0072^{***}	-0.0068^{***}	-0.0075^{***}	-0.0066^{***}	-0.0060^{***}
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Natural gas consumption	-0.0058^{***}	-0.0063^{***}	-0.0068^{***}	-0.0057^{***}	-0.0055^{***}
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Carbon emissions (total)	0.0053^{***}	0.0058^{***}	0.0059^{***}	0.0051^{***}	0.0049^{***}
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Diagnostics					
Country fixed effects	YES	YES	YES	YES	YES

Time fixed effects	YES	YES	YES	YES	YES
R^2-adjusted	0.58	0.61	0.59	0.54	0.53
AR(2)	[0.47]	[0.45]	[0.49]	[0.51]	[0.53]
Hansen Overidentification	[0.98]	[0.98]	[0.98]	[0.97]	[0.98]
Difference-in-Hansen	[0.99]	[0.99]	[0.99]	[0.99]	[0.99]
No. of instruments	14	14	14	14	14
No. of obs.	375	375	375	375	375

Notes: The lags have been determined through the Akaike criterion. pc = per capita, WGI-CC = control of corruption, WGI-VA = voice and accountability, WGI-PS = political stability, WGI-GE = government effectiveness, WGI-RQ = regulatory quality. The GMM instruments are collapsed to avoid over-proliferation following Roodman (2009). AR(2) is the test for auto-correlation of order 2 in first-differenced errors. Difference in Hansen is the test of validity of GMM instruments in the levels equation. The test of overidentification is based on the Hansen J statistic. The null hypothesis is that the instruments are valid (i.e., uncorrelated with the error term), and that the exclusions restrictions are valid (i.e., the instruments are correctly excluded from the second-stage equation). Figures in brackets denote p-values. *: p≤0.10, **: p≤0.05, ***: p≤0.01.

Robustness check

a. Estimates through the pooled common correlated effects (PCCE) method

This part of the empirical analysis uses the pooled common correlated effects (PCCE) estimator recommended by Pesaran (2006) as a robustness check. This method allows the estimates to account for unobserved common factors by augmenting the original model with cross-sectional averages of the dependent and independent variables (as proxies for the unobserved common factors), and to interact these with country-dummies in order to allow for country-specific effects. Overall, Pesaran's (2006) PCCE estimates are an ideal tool for estimating the effect of idiosyncratic polarization on renewable energy consumption. The PCCE estimator lends itself to this task, because it accounts for common factors, allows for individual-specific effects of these factors, and generates coefficient estimates based on the idiosyncratic fluctuations in the data.

The PCCE estimator partitions the model by orthogonally decomposing polarization and renewable energy consumption using their cross-sectional means. The estimation can be viewed as a two-stage regression. In the first stage, the common effects are filtered out from the data by regressing each variable on the cross-sectional averages of all variables in the model. In the second stage, the PCCE estimates of an individual coefficient are obtained by regressing the residual from the polarization equation in the first stage (i.e., capturing idiosyncratic polarization), on the residual from the renewable energy consumption equation in the first stage. These residuals are valid estimates of the idiosyncratic components and can be compared to cross-sectionally demeaned polarization and renewable energy consumption (Westerlund and Urbain, 2015). The new results are presented in Table 5. The estimates are based only on the long-run association of the control variables with renewable energy consumption, with the results providing robust support to the GMM results reported in Table 4. All of the coefficients of the control variables have same signs similar to those obtained with the system GMM. The findings with respect to the estimates of the polarization suggests that the long run elasticities of renewable energy consumption to polarization, fractionalization, ideological position difference among the parties that govern (Gov_ideo_dif), highest ideological difference among the four major parties (Major4_ideo_dif) and the ideological difference between the two major parties (Major2_ideo_dif) are -0.0102, -0.0119, -0.0150, -0.0128 and -0.0131, respectively. Based on the polarization measure used, polarization reduces renewable energy consumption by 0.0102% to 0.015%.

Table 5. Renewable energy consumption and polarization: PCCE estimates

Variables	(1)	(2)	(3)	(4)	(5)
Polarization	-0.0102***				
	[0.00]				
Fractionalization		-0.0119***			
		[0.00]			
Gov_ideo_dif			-0.0150***		
			[0.00]		
Major4_ideo_dif				-0.0128***	
				[0.00]	
Major2_ideo_dif					-0.0131***
					[0.00]

WGI-CC	0.0069***				
	[0.00]				
WGI-VA		0.0060***			
		[0.00]			
WGI-PS			0.0058***		
			[0.00]		
WGI-GE				0.0034*	
				[0.06]	
WGI-RQ					0.0049***
					[0.00]
GDP (pc)	0.0075***	0.0079***	0.0068***	0.0071***	0.0073***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Population	0.0064***	0.0069***	0.0064***	0.0070***	0.0062***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Financial development	0.0114***	0.0113***	0.0119***	0.0112***	0.0109***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
FDI	0.0169***	0.0173***	0.0165***	0.0168***	0.0154***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Oil prices	0.0138***	0.0141***	0.0136***	0.0129***	0.0137***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Natural gas prices	0.0066***	0.0069***	0.0065***	0.0063***	0.0058***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Oil consumption	-0.0083***	-0.0079***	-0.0082***	-0.0075***	-0.0067***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Natural gas consumption	-0.0064***	-0.0069***	-0.0078***	-0.0065***	-0.0063***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]
Carbon emissions (total)	0.0059***	0.0065***	0.0064***	0.0058***	0.0056***
	[0.00]	[0.00]	[0.00]	[0.00]	[0.00]

Diagnostics

Country fixed effects	YES	YES	YES	YES	YES
Time fixed effects	YES	YES	YES	YES	YES
R^2-adjusted	0.61	0.64	0.65	0.58	0.56
No. of obs.	375	375	375	375	375

Notes: The lags have been determined through the Akaike criterion. pc = per capita, WGI-CC = control of corruption, WGI-VA = voice and accountability, WGI-PS = political stability, WGI-GE = government effectiveness, WGI-RQ = regulatory quality. Figures in brackets denote p-values. *: p≤0.10, **: p≤0.05, ***: p≤0.01.

b. Panel non-causality test

As an additional robustness analysis, we also employ the panel non-causality test developed by Dumitrescu and Hurlin (2012) to test for the direction of the causation between renewable energy consumption and polarization measures. Under the null hypothesis, it is assumed that there is no causality from one variable to another. Under the alternative hypothesis, there is a causal relationship from one variable to another for a subgroup of individuals, and the coefficients may differ across groups. The results are reported in Table 6. They clearly illustrate that all definitions of polarization do Granger-cause renewable energy consumption at the 1% significance level, while the vice versa does not hold. Overall, the findings with the panel non-causality test developed by Dumitrescu and Hurlin (2012) confirms the use of the polarization measures as regressors with the system GMM and PCCE estimation methods.

Table 6. Dumitrescu and Hurlin panel Granger non-causality test results

Null hypothesis	Test values	p-values
Polarization does not cause renewable energy consumption		
Polarization → renewable energy consumption	4.98***	[0.00]
Fractionalization → renewable energy consumption	5.04***	[0.00]
Ideology difference between parties that govern → renewable energy consumption	4.84***	[0.00]
Highest ideological difference among 4 major parties → renewable energy consumption	4.96***	[0.00]
Ideological difference among 2 major parties → renewable energy consumption	5.37***	[0.00]
Renewable energy consumption → polarization	0.68	[0.17]
Renewable energy consumption → fractionalization	0.63	[0.21]
Renewable energy consumption → ideology difference between parties that govern	0.59	[0.24]
Renewable energy consumption → highest ideological difference among 4 major parties	0.62	[0.20]
Renewable energy consumption → ideological difference among 2 major parties	0.64	[0.18]

Note: ***: $p \leq 0.01$.

5. Conclusion and Policy Implications

There is a growing body of literature examining the determinants of renewable energy consumption, given that renewable energy is a mechanism through which countries can mitigate the negative consequences of climate change and global warming and improve their energy security. Most of the existing literature has focused on the macroeconomic, environmental, institutional, and energy-related factors, while exploring the determinants of renewable energy consumption and neglecting the potential effect of the political context. Even though there exists some literature examining the role of the ideological stance of the governments for the consumption of renewable energy (Cadoret and Padovano, 2016), these studies have ignored how partisan polarization may affect the policymaking on environmental issues and hence its effect on the renewable energy consumption. To fill this gap, we examined the association between renewable energy consumption and partisan polarization in 25 European Union countries during the period 2003-2017; the findings documented that party polarization lowered the levels of renewable energy consumption after controlling for certain determinants of renewable energy. The analysis also used three sets of methods (GMM, PCCE, and panel non-causality) and five measures of polarization, the results remained robust to the use of a different set of methods and polarization measures.

The findings highlight another negative implication of party polarization, where it also leads to lower levels of renewable energy consumption beyond the existing adverse effects. To mitigate the negative impact of party polarization on renewable energy consumption, politicians could explicitly take into account the importance of framing climate change policies (Krantz and Monroe, 2016; Jones et al., 2017; Chu and Yang, 2018). For instance, Chu and Yang (2018) showed that ideological polarization in climate change perception could be reduced when climate change impact was portrayed as influencing a spatially close and familiar exemplar, compared to a spatially distant and novel exemplar. In other words, it is possible that the detrimental effect of party polarization could be mitigated by framing environmental policies differently to promote public and political support for renewable energy consumption.

One of the main reasons for the rise of the political polarization and rise of discontent and populism in the EU is the increased economic disparities across the EU territories (see, e.g., Noury and Roland, 2020; Dijkstra et al., 2020). Therefore, some of the EU structural funds could be coupled with the renewable energy funds to target territories that are declining economically to promote renewable energy production in these regions and improve the economic conditions. For instance, one of the EU funding schemes is the “Just Transition Mechanism”, which aims to help mobilize at least €150 billion over 2021-2027 to support a climate-neutral economy, which could be used to target territories that are left behind economically. Region-specific allocation of such funds is likely to generate economic prosperity and generate greener jobs and alleviate some of the negative consequences of political polarization on renewable energy deployment.

We also found that the countries with better institutions, with higher economic and financial development, use higher renewable energy. Therefore, EU policies aiming to improve economic and financial development and institutional settings would also contribute to renewable energy targets. The policymakers in the EU could also consider including tax policies on the national targets of the countries on the nonrenewable energy consumption (i.e., natural gas and oil) and/or subsidize renewable energy consumption during high natural gas and oil prices to promote member states to use more of renewable energy.

There are also potential future research agendas in this nexus. In this paper, we examined the direct role of political polarization for renewable energy consumption at the country level. However, a future study could examine the role of regional political factors for renewable energy deployment. Furthermore, a future study could examine the indirect channels through which political polarization affects renewable energy consumption. In other words, it is possible that the political polarization could affect some of the main macroeconomic, environmental, institutional, and energy-related determinants of renewable energy consumption. Henceforth, a future study examining the indirect effects of partisan polarization would be a worthwhile research area.

Appendix. Country list (25)

Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, UK

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