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Research Article

Renewable Energy Consumption in G-7 Countries: Evidence from a Dynamic Panel Investigation

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The necessity of transitioning from the fossil fuels era to a green economy based on renewable energy resources has become increasingly urgent. This is in order to minimize the impact of energy supply fluctuations and combat global warming, especially in the wake of the recent oil price shock due to the Russian invasion of Ukraine. The present study is aimed at identifying and analyzing the most influential variables affecting renewable energy consumption (REC) among the G-7 countries using a log-linear dynamic panel model that covers the data period from 1996 to 2018. The results indicated that foreign direct investment (FDI) and regulatory quality index (RQI) have negative impacts on REC, while urbanization and GDP per capita have positive influences. Furthermore, urbanization has the highest absolute value coefficient, which is equal to 1.26. This means that a one percent increase in urban population will lead to about a 1.26 percent increase in REC. This finding highlights the importance of planned urbanization and converting buildings and houses into environmentally friendly structures to promote REC. Also, the positive effect of GDP per capita on REC suggests that stable economic growth will enhance the share of REC in total energy consumption. Thus, the countries should robust their economies against exogenous shocks like energy price jumps. Finally, a two-stage Granger-type cointegration test showed that the variables are in a long-run and stable relationship, which implies the reliability of the research findings.

1. Introduction

Since the signing of the Kyoto Protocol by 84 countries during 1992-1999, climate change and the need to reduce carbon emissions, especially from fossil fuels, have been on the radar of social movements and political parties worldwide. The recent severe oil price shock caused by the Russian invasion of Ukraine has again put the idea of an oil-free economy on the table, particularly for European countries. Consequently, most countries are increasing energy production from renewable sources and nuclear plants. This measure is particularly important for Europe, as Norway, the major European oil and natural gas producer, can only cover about 20% of the overall regional consumption, and importing from the USA and Canada is more expensive than importing from Russia. As a result, increasing electricity production from renewable resources will be necessary in the long term.

To understand the share of renewable sources in the total energy basket, it would be useful to review international energy data. According to the British Petroleum report [1], the share of renewable power from the world's primary energy is about 11%, which is not significant. However, Iceland produces almost 85% of its energy from renewable sources, particularly geothermal plants. Additionally, according to BP's report, the share of secondary power sources for oil-based economies like OPEC members is almost negligible. While some well-developed countries are working to increase the share of renewable energy from total power consumption, there is still a long way to go to achieve oil-free economies, particularly for the least-developed countries.

The present study is intended to focus on the major determinants of energy consumption of the G-7 group: the USA, the UK, Japan, Germany, Canada, France, and Italy. This decision has been made because the USA is the biggest carbon dioxide emitter in the world. Also, Canada's well-developed oil industries, especially with the shale oil mines in Calgary, are chief threats to the ecosystem of North America and the Alaska territory. Moreover, Japan and Germany are the two world's major energy consumers. Besides, the technologies of renewable energy production mostly have originated from these countries, and this industrialized team produces about 40 percent of the total world's GDP (World Bank's Database at: http://www.data.worldbank.org) [2]. This group of countries has sufficient financial sources to pay subsidies to their citizens who try to increase renewable energy consumption by, for example, establishing solar panels on the roof of their buildings. However, low-income countries have no such capabilities, and developing ones have other priorities than environmental concerns. In fact, developing countries have to invest in their infrastructures in order to maintain a stable growth rate. As a result, higher-income countries have superior environmental awareness that pushes them towards more energy consumption from renewable sources [3]. So, analyzing the G-7 group will be a key to understanding the world's trends towards a carbon-free economy. The present research has attempted by employing a causal model to show how the fluctuations in the macroeconomic variables should be calibrated to maximize renewable energy consumption subject to the realistic restrictions imposed by international trade and governments.

Sustainable development is another concept that motivates countries to use renewable energy sources. The scientific fact is that the fossil fuel resources in most countries will be ended throughout the current century. Moreover, there will not be stable growth or production without sufficient energy resources. As a result, most countries constantly attempt to increase the share of renewable power in the total basket of energy consumption [4]. The important issue is that the oil price shocks have substantial effects on renewable energy demand. Several researchers, including Maghyereh and Abdoh [5], Zhao [6], and Mukhtarov et al. [7], analyzed this relationship by conducting empirical studies across the world. However, they failed to conclude what will happen if the shocks push countries towards sustainable development, because they had not considered the effect of social variables on renewable energy consumption trends.

This present study has investigated the nexus between aggregate variables and the share of renewable resources from primary energy by using a dynamic panel model. The novelty and the main contributions of this research can be noted as follows. (i) Although several studies have analyzed this relationship so far, the present research is a pioneer of its kind because in this research, for the first time, the effects of the most influential socioeconomic variables, including quality of governance and the core target consumers (urban population), on renewable energy consumption have been analyzed. In this sense, this study can be categorized as socioeconomic research that has simultaneously considered the effects of social and economic variables on renewable energy consumption. The study has chosen this path because consumption is a phenomenon beyond classical rational theories. For example, some people invest their money in environmental-friendly companies to support the green parties without considering the alternative firms in the sense of the rate of return. So, the classical theory of rational consumers cannot describe their financial decisions because these investors are not profit maximizers. As a result, incorporating social variables in studying the phenomenon related to consumption is inevitable. (ii) Furthermore, in order to provide a pattern for future policy implications, this study has attempted to illustrate the interactions of variables by employing a dynamic framework. (iii) A justification for selecting the G-7 countries for the analysis of renewable energy consumption has been presented above by providing suitable logic and data. We have argued that G-7 countries are the most appropriate sample countries for conducting such research. Thus, the contribution of this research to the literature of energy economics is notable.

The paper is structured as follows. The second part presents the theoretical framework and a literature review. The third section provides an explanation of the data, variables, and modeling approaches. The fourth section discusses and evaluates research findings. Finally, concluding remarks and policy implications are presented in the last section.

2. Theory and Literature Review

In conventional economic literature, there is no comprehensive theoretical framework describing the nexus between energy consumption and aggregate variables such as GDP or capital formation. For instance, in the neoclassical growth theory of Solow-Swan, production is a function of the labor force, capital, and technology [8]. However, technology cannot be considered a direct function of energy demand. That means there is no reason to claim that an increase or decrease in energy consumption will lead to fluctuations in technological enhancement. Therefore, the only solution is to investigate their dynamics through empirical studies. In fact, finding the appropriate variables collection and causal model that describes the fluctuations in the relationship between renewable energy consumption and the influential variables is the main issue in theory-free empirical analyses. Therefore, this study will examine the relationship between those variables by employing a socioeconomic approach. In this regard, the selected variables will contain both economic and demographical/social elements.

There is a common belief that promoting production levels requires a higher volume of energy. However, this cannot be considered a general rule as the source of production and the nature of final goods or services are key factors that determine the amount of energy consumption. Moreover, this variable can vary across countries and companies due to relative advantages. For example, an increase in agricultural products does not necessarily correspond with a higher amount of energy demand. The key factors that determine the volume of production in the agricultural sector are access to high-quality land and soil, sufficient water resources, and protection from plant pests. In contrast, in industrialized economies, the link between energy consumption and production levels seems to be strong [9]. In this regard, Yuan et al. [10] used a cointegration study in China's economy to show that there is a long-run relationship between total output, labor force, level of capital, and energy consumption. They found a causal direction from GDP to energy consumption, but not a bidirectional nexus. Ren et al. [11] analyzed the linkage between economic growth and energy consumption in a panel of 26 provinces in China for a period of 23 years by employing a novel nonparametric method. They concluded that such a relationship exists, but it follows a time-varying pattern. Ultimately, they stated that to combat the increasing trend of carbon emissions in China, the provinces with low-carbon emissions need special attention and more investments. Further, when analyzing the relationship between energy consumption and economic growth, the energy source should also be considered. For example, Isik [12] investigated the nexus between natural gas consumption and GDP growth in Turkey during 1977-2008. He concluded that while natural gas has a positive impact in the short run, it damages Turkey's economy in the long term. This outcome shows that energy consumption could have dual effects on aggregate outputs.

As renewable energy is an integral component of the total energy basket (primary energy), an increase in energy demand may enhance renewable energy production, especially in well-developed countries. For this purpose, Rahman and Sultana [13] investigated the most important factors influencing renewable energy production using a panel ARDL study through 19 countries from 2002 to 2019. They concluded that institutional quality, economic growth, and export levels significantly affect renewable energy production. Saqib [14] studied the relationship among green energy, nonrenewable energy, financial development, and economic development with a carbon footprint using a panel estimation of 63 countries for the period of 1990-2020. He stated that all the variables are cointegrated, and there is also a bidirectional correlation between financial development and economic growth. Magazzino et al. [15] examined the correlation between renewable energy consumption, economic growth, and CO2 emissions in a panel of five Scandinavian countries from 1990 to 2018. The results showed that increasing green energy consumption can significantly reduce carbon dioxide emissions without any negative impact on the GDP. By using a similar perspective, Rahman [16] analyzed the nexus between energy consumption, FDI, economic growth, and international trade, employing a panel study of BRICS and ASEAN countries for 28 years. He showed that there is a long-run relationship between those variables. Furthermore, there is a bidirectional relationship between energy consumption and economic growth in addition to a unidirectional causality from the GDP to the FDI. In an extensive analysis, Aydin and Pata [17] investigated renewable energy consumption in the USA by introducing a novel wavelet-based unit root test. They concluded that the renewable energy policies in the country affect all the sources of the consumption except hydropower and biofuels. In another interesting study, Mele et al. [18] examined the impact of renewable energy on the GDP growth recovery of Brazil after the COVID-19 pandemic recession. For this purpose, they used a recurrent neural network machine learning technique known as a long short-term memory network (LSTM). They concluded that an increase in renewable energy consumption leads to a gentle and sustainable economic recovery compared to other energy sources. In an innovative study, Isik et al. [19] investigated the possible nonlinear nexus between renewable energy consumption and economic growth by employing a bootstrap panel Granger causality test using a collection of seven countries. They came to the conclusion that while there was a bidirectional connection in the case of the USA and Italy, a unidirectional nexus from GDP towards green energy consumption was confirmed in China, Turkey, and Germany. In that sense, the unidirectional causality implies that an increase in GDP will lead to an increment in renewable energy consumption. Interestingly, the outcomes were in favor of the green energy-led growth theory in Spain. In contrast, Magazzino [20], by analyzing the relationship between the consumption from renewable energy sources and GDP growth in Italy for 38 years, confirmed the existence of a reverse long-run nexus. Within that context, he highlighted that a one percent increase in green energy consumption in Italy would lead to about a 0.23 percent decline in economic growth. In another well-structured research, Ocal and Aslan [21] analyzed the correlation between renewable energy consumption and economic growth in Turkey by utilizing an ARDL approach. They found that the variables were negatively interrelated. Moreover, Toda and Yamamoto's [22] causality test revealed there was a unidirectional causality from the GDP to renewable energy consumption. Fotourehchi [23] also studied the nexus between renewable energy consumption and economic growth using a panel analysis among 42 developing countries during 1990-2012. She concluded that renewable energy consumption has a positive long-run relationship with GDP growth. Ultimately, Rahman and Velayutham [24], in their empirical research, found a unidirectional causality from economic growth to renewable energy consumption in South Asia. All the mentioned studies have confirmed there is a positive relationship between production levels and renewable energy consumption; however, there was no agreement on the direction of causality and stability of their nexus.

Capital flows, specifically foreign direct investment, is the other influential factor used in most macroanalysis, especially in the energy sector. To illustrate that link, Fan and Hao [25] investigated the relationship between FDI, GDP, and renewable energy consumption in China during 2000-2015. Although the empirical results confirmed a long-run comovement among the variables, the FDI had no significant impact on renewable energy consumption in the short run. In this regard, Kilicarslan [26] studied the correlation between FDI and renewable energy production in a panel of the BRICS countries plus Turkey during 1996-2015. The outcomes were in support of Hao's conclusion and displayed there was a long run and positive relationship between those variables. In a related investigation, Khan et al. [27] analyzed the long-run relationship between renewable energy consumption, openness to trade, FDI, and carbon emissions through two distinct panels, one for developed and another for developing countries. They confirmed that all the variables were in a long-run relationship for both panels. In another study, Paramati et al. [28] analyzed the effect of FDI and stock market developments on renewable energy consumption using a panel model including 20 countries during 1991-2012. The results revealed that FDI, the GDP, and stock market developments had influenced green energy consumption positively. In addition, a panel causality test demonstrated that there was a unidirectional relationship between FDI and renewable energy use. Furthermore, Sbia et al. [29] researched the interconnections among FDI, green energy, trade openness, carbon dioxide emission, and the GDP in the United Arab Emirates using quarterly data from 1975 to 2011. They concluded that the variables were cointegrated; however, FDI and trade openness had affected energy demand negatively, while the GDP had a positive impact. In a remarkable investigation, Ibrahiem [30] conducted an ARDL analysis of the relationship between FDI, renewable electricity consumption, and GDP in Egypt during 1980-2011. The results indicated that the variables were cointegrated, and there was a bidirectional causality between economic growth and renewable energy consumption. However, the test showed that there was no causality between FDI and energy consumption. In summary, it can be stated that the relationship between FDI and the renewable energy consumption is associated with several uncertainties. However, the ambiguous nature of their link can be attributed to a nonlinear causality. Therefore, further consideration about considering the impact of FDI on renewable energy consumption is inevitable.

There is no doubt that establishing renewable energy infrastructures is an investment with low rates of returns. Therefore, a short payback period could explain why most companies and governments prefer to invest in fossil fuel industries instead of renewable energy facilities. However, since the primary resources of renewable energies are almost free, easily accessible, and without any supply restrictions, in the long run, they can provide higher financial profits compared to traditional energy platforms. For example, establishing solar panels on the roof of a building sounds like a wrong investment, especially in countries paying high energy subsidies. Nevertheless, in the long run, it not only covers some part of household electricity consumption for free but also provides a chance to sell the surplus electricity to the local government or municipality. For that logic, in some countries, particularly in Western Europe and North America, solar panels have been turned into a routine part of buildings. So, hypothetically, any increase in the number of buildings can be associated with higher renewable energy production. On the other hand, an increment in the number of buildings is a consequence of upward trends in urbanization. As a result, it can be argued that an increase in the urban population may enhance the total energy produced from renewable sources. For instance, Vo D. and Vo A. [31] examined the relationship between renewable energy consumption and population growth in Southeast Asia using a panel causality test. They realized that renewable energy demand positively responded to population growth, specifically the urban population. Importantly, the urban population and the economic growth together can explain most of the changes in energy consumption patterns in the region. In another study, Pata [32] analyzed the relationship between renewable energy consumption, urbanization, CO2 emissions, and financial development in Turkey for the period 1974-2014. The outcomes confirmed a long-run nexus among the variables. However, GDP growth and urbanization had the worst impact on carbon dioxide emissions. Moreover, the study showed that increasing energy consumption from renewable resources could not help to slow down the upward trends of CO2 emissions in Turkey. In an interesting research, Zhao and Zhang [33] investigated the correlation between urbanization and energy consumption in China. Their study revealed that from 1980 to 2010, a one percent increase in the urban population was associated with a 1.4 percent promotion in total energy consumption. Sheng et al. [34] analyzed the impact of urbanization on energy consumption and energy efficiency using a panel study of 78 countries from 1995 to 2012. They came to the conclusion that urbanization has increased energy consumption; however, it has also decreased the efficiency of the used energy. In addition, Bakirtas and Akpolat [35] examined the causal relationship between energy consumption, urbanization, and economic growth in a panel of six countries for 44 years. They concluded that there was bidirectional causality among all three variables. Furthermore, Asif et al. [36] studied the relationship between the GDP growth rates, urbanization, energy consumption, and carbon emissions in the GCC countries employing a panel model during 1980-2011. Their results highlighted that the variables were in a long-run relationship, and urbanization had a positive impact on energy consumption while economic growth had a negative influence. In summary, all the mentioned studies concluded that the urban population has a direct relationship with renewable energy consumption, particularly in the long run, but it decreases energy efficiency. It is a crucial link because in all the G-7 countries, the urban population has constructed about 90 percent of the total population, and therefore, its effect cannot be ignored.

The regulatory quality index (RQI), also known as the government efficiency measurement, is one of the most cited variables in socioeconomic and political studies. RQI is a real number that lies in the interval of 0 and 1. The higher values indicate more efficient performance, while values less than 0.5 often represent systematic corruption. Therefore, this variable can be accounted as the degree of democratic governance and the effectiveness of public surveillance. Albeit its impact on the macroeconomic variables has not been completely investigated, the higher scores do not necessarily imply better economic performance. In fact, superior values can be accompanied by a more complicated decision-making process. For example, Switzerland's RQI is about 0.95 on average; however, almost for all national decisions, the government has been obligated to ask people's opinions directly through a referendum, even for constructing an interstate highway. In contrast, the RQI for authoritarian governments, like most OPEC organization members, is about 0.5. Nevertheless, the decision-making procedure in those nondemocratic countries is short, fast, and efficient because, in most cases, the king, the supreme leader, or the president dictates the rules, and all the bureaucrats and citizens have to abide. On the other hand, the RQI can show how much the government's decisions have complied with actual economic conditions. For instance, in an oil-based economy like Saudi Arabia, investment in petroleum industries has higher returns compared to other alternatives. For illustration, in 2014, the average cost of crude oil production from the Ghawar field in Saudi Arabia was about \$7 per barrel, but this value was about \$21 in offshore fields of Norway and \$51 in Bakken shale in the United States. So, with about \$10 per barrel cost of production on average, Saudi Arabia has the lowest production cost among all the oil-producing countries [37]. Besides, the annual average price of the OPEC oil basket in 2014 was about \$96 per barrel [38]. As a result, in 2014, the marginal profit of producing one barrel of crude oil in Saudi Arabia was about \$86 or 860 percent. Despite that economic fact, the country has signed a contract with a consortium of European and Asian companies to establish the world's biggest solar panel farm near the capital, with a rough estimation of a total investment of about 200 billion USD until 2030 horizon (Aljazeera News Agency at: http://www.aljazeera.com/economy/2018/3/28/saudi-arabia-to-create-worlds-biggest-solar-power-firm) [39]. However, since the country has a massive resource of low-cost crude oil and natural gas, producing electricity from these resources is several times cheaper than renewable sources. That means the contract is nothing more than a political gesture to promote the country's rank in international societies by introducing Saudi Arabia as a responsible country. In sum, the mentioned contract cannot be considered a rational economic decision, but in this case, the low RQI has been associated with higher renewable energy production. In a pioneer study, Wang et al. [40] investigated the effect of political connections of Chinese companies on their environmental damages for a large panel of selective firms. Their study can be considered the relationship between RQI and environmental collateral damages of producing companies since the interconnection between politics and business generally declines the RQI. The authors confirmed a nonlinear relationship and suggested to achieve sustainable environmental-friendly development, establishing some restrictive rules. Although the research outcomes validated the nexus between RQI and environmental degradation, it was silent about its relationship with renewable energy consumption. In fact, it can be argued that by increasing the RQI, some major companies will lose their political protections. On the other hand, as a rule of thumb, investing in renewable energy plants has a low rate of returns with a long payback period. Consequently, firms' motivation to support green political parties through performing renewable energy projects will be declined. Therefore, it can be claimed that the higher RQI will be associated with lower renewable energy consumption. In summary, higher values of RQI cause a slow but rational decision-making process and vice versa. As a result, the effect of the RQI on the overall economy can be negative, but seemingly it may boost the FDI by increasing the government's transparency. Therefore, incorporating RQI into the model is not only an appropriate variable selection but also can bridge the existing gap in analyzing the impact of efficient governance on renewable energy consumption.

3. Data, Model, and Findings

3.1. Data and Variables. The previous section has provided a clear perspective on the most influential factors affecting renewable energy consumption. As a result, this study has concluded that the basic model should contain the five fundamental socioeconomic variables, including renewable energy consumption (RE) as the dependent variable, and four explanatory variables: the foreign direct investment (FDI), the GDP per capita (GDPPC), the regulatory quality index (RQI), and the urban population (URB). The explanatory variables have been chosen as proxies for capital flows or capital formation, economic growth, quality of governance, and target consumer community, respectively.

Since the study has targeted the G-7 group, hence by nature, the research will deal with panel data. In this regard, the cross-sections are equal to the number of countries ($N = 7$), and the time interval is restricted to annual records for 1996-2018 ($T = 23$). So, the panel includes $N.T = 161$ composed data.

The data for the dependent variable have been collected from the British Petroleum annual statistical reviews [41], and the data of all explanatory variables have been acquired from the World Bank database. Unfortunately, since there are no reported annual data for RQI in 1997, 1999, and 2001, even in alternative databases, the missing data have been interpolated using an exponentially weighted moving average technique. Furthermore, the logarithmically transformed version of variables has been used to minimize the possible effect of heteroscedasticity. Moreover, since we are using log-linear models, the estimated coefficients represent direct elasticities. This transformation will provide the opportunity for causal inference.

3.2. Modeling and Statistical Inference. Before entering into the modeling step, the data were subjected to a preprocessing procedure to provide a better picture of the panel's nature and possible upcoming issues.

3.2.1. Correlation Matrix. The correlation coefficients and their implied matrix will provide an initial understanding of the direction of the variables' comovement. It can also be considered the first estimation of the model's coefficients. Since the matrix is symmetric with respect to the main diagonal, its lower triangular version is reported in Table 1.

As can be deduced, Log(GDPPC) has the highest effect on the Log(RE), and the lowest belongs to Log(URB). In fact, except for GDP per capita, the impacts of other variables are negative. The positive coefficient for GDP can be deceptive because this relationship is generally being extended to countries other than the selected group. For example, Qatar has one of the highest GDP per capita in the world, but almost all the country's wealth has been obtained from LNG export revenues. Due to the seemingly unlimited reserves of petroleum products, natural gas in

Table 1: Correlation matrix.

	Log(RE)	Log(FDI)	Log(GDPPC)	Log(RQI)	Log(URP)
Log(RE)	1.0000				
Log(FDI)	-0.1440	1.0000			
Log(GDPPC)	0.2145	0.2892	1.0000		
Log(RQI)	-0.0840	0.5614	0.2633	1.0000	
Log(URB)	-0.0248	0.1075	0.4545	0.4241	1.0000

Table 2: Cross-section dependence tests.

	Breusch-Pagan LM	Pesaran LM
Log(FDI)	59.3792 (0.0000)	5.9220 (0.0000)
Log(GDPPC)	325.6976 (0.0000)	47.0159 (0.0000)
Log(RE)	261.2238 (0.0000)	37.0673 (0.0000)
Log(RQI)	112.4945 (0.0000)	14.1179 (0.0000)
Log(URB)	435.3035 (0.0000)	63.9284 (0.0000)

The values in the parentheses indicate the probability of the statistic.

the country is nearly free for citizens, and thus, renewable energy consumption is almost equal to zero. An interesting point about Table 1 is that all the exogenous variables have positive pairwise correlation, which can be a sign of cointegration and appropriate variable selection. However, achieving a reliable conclusion needs further evaluation. Besides, as had been predicted, the RQI and the FDI have the highest mutual correlation coefficient.

3.2.2. Cross-Section Dependence. In dealing with panel data, the possibility of dependency or correlation among some parts of cross-sections is substantially high. The relationship is similar to cross-correlation, but the nexus is among cross-sections instead of variables. This phenomenon will fundamentally affect the statistical inference, including the unit root and cointegration tests. For instance, the first-generation panel unit root tests assume cross-section independence, while the second-generation tests have relaxed this presumption. To investigate this feature, Breusch and Pagan [42] and Pesaran [43] tests have been employed, and their outcome is provided in Table 2.

The results confirm the cross-sectional dependence at a five percent significance level for all the variables. In fact, it was not a surprising outcome because the G-7 countries have several similarities and economic ties. All seven countries are highly industrialized with significant levels of real GDP and also have been considered well-established democracies with high levels of RQI. Furthermore, due to the massive economic output, their energy consumption is substantially higher than other countries, except China. Therefore, since, during recent years, the economic and financial integration of the G-7 group has increased, the cross-sectional dependence should be considered an inevitable outcome [44].

3.2.3. Unit Root Tests. As there exists a cross-sectional dependence of variables, the second-generation unit root tests should be employed. In this regard, two tests by Pesaran [45] and Bai and Ng [46], known as PANIC, have been used. Pesaran's test takes the advantage of two statistics known as CIPS and truncated CIPS to investigate the presence of unit roots, while PANIC's null hypotheses consider nonstationary behavior. It should be mentioned that the truncated version of CIPS has better performance in the case of a relatively small number of cross-sections and limited time domain. The outcomes of the tests are reported in Table 3.

It can be concluded from Table 3 that Log(RE) and Log(GDPPC) have unit roots while the Log(RQI) is stationary. Log(FDI) is neither stable nor has a unit root. So, a mean-reverting process with a fractional unit root would be desired; nevertheless, further analysis is out of the scope of this study. Finally, there is no sign of unit root in the Log(URB), but since there is no information from PANIC tests, the decision about its stationarity is not feasible. In sum, since the model has at least two variables with unit roots, consideration of a cointegrated vector, at least, can be a reasonable hypothesis.

3.2.4. Causality Analysis. Before any estimation, a panel causality test between the dependent and explanatory variables needs to be performed. The test results can be used for statistical inference about the estimated coefficients and the type of possible relationships, either linear or nonlinear. In this regard, the Dumitrescu and Hurlin [47] test has been used, and its outcomes are reported in Table 4.

As can be seen, the Log(RE) is caused only by Log(URB) and Log(GDPPC), and thus, it is highly likely that these variables will be statistically significant in the estimated model. Moreover, since there is no causal direction from the Log(RE) towards the four explanatory variables, there are no endogenous interactions, and hence, they were correctly selected as exogenous variables. However, this test is just a linear causality test and cannot identify possible nonlinear indications among the variables. So, removing the variables based on the just according to the outcomes of the test can harm the model's framework and its economic inferences.

3.2.5. Modeling. An ARDL could be the most obvious selection for a dynamic linear model; however, this model is well-suited to panels with large T and medium N. Since the time interval is not sufficiently large, estimating a restricted

Table 3: Unit root tests.

	Bai and Ng PANIC test (MCQ)			Pesaran CIPS test		
	Common factors		Idiosyncratic elements	CIPS	Truncated CIPS	
	Common trends	Statistic	Statistic	Statistic	Statistic	Critical value (5%)
Log(RE)	5	6.6254 (0.9999)	-0.3297 (0.7416)	-3.0736	-2.4202	-2.34
Log(FDI)	6	72.1479 (0.9999)	0.4156 (0.6770)	-2.3208	-2.3208	-2.34
Log(GDPPC)	6	6.2009 (0.9999)	6.3477 (0.0000)	-3.6971	-2.4161	-2.34
Log(RQI)	6	13.8093 (0.9999)	-2.0527 (0.0401)	-1.6290	-1.6290	-2.34
Log(URB)	N/A	N/A	N/A	1.3300	-0.2996	-2.34

The values in the parentheses indicate the probability of the statistic. N/As were obtained due to the near singular matrix in calculating the test statistic.

Table 4: Causality test.

Null hypothesis	*W*-stat	*Z*-bar stat	Prob	Direction
Log(FDI) does not homogenously cause Log(RE)	1.6220	-0.6653	0.5058	No direction
Log(RE) does not homogenously cause Log(FDI)	1.7707	-0.5162	0.6057	No direction
Log(GDPPC) does not homogenously cause Log(RE)	7.2106	4.9369	8.E-07	Log(GDPPE) ⟶ Log(RE)
Log(RE) does not homogenously cause Log(GDPPC)	2.3376	0.0520	0.9585	No direction
Log(RQI) does not homogenously cause Log(RE)	2.5179	0.2327	0.8160	No direction
Log(RE) does not homogenously cause Log(RQI)	2.4630	0.1777	0.8589	No direction
Log(URB) does not homogenously cause Log(RE)	8.0573	5.7856	7.E-09	Log(URP) ⟶ Log(RE)
Log(RE) does not homogenously cause Log(URB)	3.9657	1.6841	0.0922	No direction

Table 5: Lag selection.

Lag (*i*)	AIC	SBC
5	-1.8523	-1.7172
4	-1.8502	-1.7216
3	-1.8543	-1.7703
2	-1.8276	-1.7666
1	-1.8551*	-1.8156 *

The * symbol indicates the best lag.

ARDL model using just the lags of the dependent variable will be desired. To identify the best autoregressive component, the Akaike information criteria (AIC) and the Schwarz Bayesian criteria (SBC) have been used by estimating separate alternative models for Log(RE) as follows:

$$\text{Log}(\text{RE}_{\text{it}}) = C + \sum_{j=1}^{5} \text{Log}\left(\text{RE}_{i(t-j)}\right) + \varepsilon_{it} \quad i = 1, 2, \cdots, 7. \quad (1)$$

The results for the optimum lag selection are reported in Table 5.

According to Table 5, the first lag of the dependent variable is the most informative autoregressive element.

As mentioned earlier, adding the first lag of the dependent variable to the list of explanatory variables will lead to a dynamic model. However, after this change, an OLS estimator will lead to inconsistent and biased approximations [48]. To overcome this issue, a generalized moments of method (GMM) has been employed as an alternative technique. Newey and McFadden [49] showed in theorem 2.6 that the GMM estimator of the model's coefficients is consistent. Besides, Hayashi [50], in proposition 7.10, displayed that GMM is an asymptotically normal estimator. Therefore, the GMM approach has substantial advantages compared to OLS or WLS estimators. Moreover, to avoid autocorrelation and heteroscedasticity, the GMM weights have been selected based on the 2SLS method, and GLS weights have been chosen based on cross-section weights. It should be mentioned that while the one-step GMM estimator may lead to augmented covariance estimation in dynamic panel models, a two-step system GMM estimation is consistent in the presence of cross-section dependence [51]. In this regard, the general structure of the model is specified as follows:

$$\text{RE}_{\text{it}} = F(\text{RE}_{\text{it}-1}, \text{FDI}_{\text{it}}, \text{GDPPC}_{\text{it}}, \text{RQI}_{\text{it}}, \text{URB}_{\text{it}}), \quad (2)$$

And therefore, the linear-logarithmic transformed version of the model is as follows:

$$\begin{aligned} \text{Log}(\text{RE}_{\text{it}}) = \beta_1 &+ \beta_2 \text{Log}(\text{RE}_{\text{it}-1}) + \beta_3 \text{Log}(\text{FDI}_{\text{it}}) \\ &+ \beta_4 \text{Log}(\text{GDPPC}_{\text{it}}) + \beta_5 \text{Log}(\text{RQI}_{\text{it}}) \\ &+ \beta_6 \text{Log}(\text{URB}_{\text{it}}) + \varepsilon_{\text{it}}. \end{aligned} \quad (3)$$

The estimated results of the model and its statistical inferences are reported in Tables 6–9 as follows:

The outcomes obtained in Table 6 indicate that the null hypothesis of pooled data has been rejected, and hence, the

Table 6: Redundant fixed effects.

Effects test	Statistic	d.f	Prob
Cross-section F	2.4460	(6, 140)	0.0280

Table 7: Dynamic model estimation.

	Panel GMM EGLS estimation		
Variable	Coefficient	t-statistic	Prob
Log(RE(−1))	0.9535	47.5105	0.0010
Log(FDI)	-0.0060	-0.2391	0.8114
Log(GDPPC)	0.0607	1.7065	0.0902
Log(RQI)	-0.2190	-2.0105	0.0464
Log(URB)	1.2587	2.5018	0.0136
R-Sq	0.9940		
Adjusted R-Sq	0.9935		
Sargan test			
Statistic	Value	Instrument Rank	Prob
J-stat	0.0156	13	0.9006

Table 8: Residual diagnostics.

Test	Statistic	Prob
A. Cross-section dependence test		
Breusch-Pagan LM	32.9281	0.0470
Pesaran Scaled LM	1.8405	0.0657
Pesaran CD	-1.2348	0.2169
Bias-corrected scaled LM	1.6655	0.0958
B. Normality test		
Jarque-Bera	0.2162	0.8975

Table 9: Residuals unit root tests.

Method	Statistic	Prob
Im et al.	-4.7795	0.0010
ADF-Fisher Chi-Sq	48.6850	0.0010
Hadri Z-Stat	0.1065	0.4576

study correctly assumed a panel model. In fact, the chance of having a pooled database would be substantially low when the countries do not belong to the same region and their demographic features are different. For example, if the Nordic countries were under investigation, the possibility of accepting the hypothesis of pooled data was quite significant. According to Table 7, the Adjusted R-square statistic shows one of the highest possible explanatory powers. However, it should be mentioned that the adjusted R-square for a static model could be lower than the value achieved through a dynamic approach because adding the first lag of the dependent variable has drastically reduced the effect of possible omitted variables. Besides, the Sargan [52] test results have approved the suitability of employed instrumental variables. The t-statistic outcomes have confirmed the statistical significance at a 10 percent level of all variables except for Log(FDI). An interesting point is that while the correlation coefficient between Log(RE) and Log(URB) was negative, it had the highest positive impact on the response variable. That result indicates that the outcomes of the correlation table were not accurate, or maybe the effect of the dynamical framework has changed the nature of the relationship. Another possible explanation is that the Pearson correlation assumes the data are I.I.D and distributed normally, but this panel of data clearly has violated those presumptions, and thus, the correlation coefficients were not reliable. Table 8 displays that the residuals are cross-sectional independent, and Jarque and Bera's [53] test approved that the innovations have been distributed normally. Therefore, since the classical assumption has been satisfied, the results of the t-statistic are valid, and the estimated coefficients are consistent and unbiased. It should be mentioned that even if the error term follows a nonnormal distribution, the statistical inference could be possible. Still, the conventional t-statistic will lead to an inflated estimation. In that case, taking advantage of Hall's [54] procedure would be desired [55]. Finally, due to the independence of cross-sections, the first-generation unit root tests of Im et al. [56] and Maddala and Wu [57] ADF-Fisher have been used for possible unit root identification. In addition, the Hadri [58] test has been employed to check if the residuals are stationary. The results reported in Table 9 indicate that the residuals are stationary, and hence, the regression is genuine. That means the variables are in a long-run relationship, and the estimated coefficients construct a cointegration vector. It should be mentioned that since the GMM technique takes benefits from instrumental variables (IV), the inappropriate selection of IVs could lead to poor estimation and even the lack of cointegration. However, Sargan's test has confirmed the adequacy of the used IVs. Therefore, the estimation is robust to instrumental variables' bias. Moreover, since the GMM asymptotically is a normal and consistent estimator, changing of method will not alter the outcomes. Nevertheless, the new technique should be robust to cross-sectional dependence. In this study, use of the two-step GMM system has made the results robust to cross-sectional dependence bias emitted from exogenous variables throughout the model. Finally, since the variables are cointegrated, it rejects the possibility of spurious regression and implies a genuine model.

4. Discussion of Findings

The logarithmic transformation of the variables was used to ensure a causal and understandable interpretation. The panel causality test revealed two unidirectional causalities from GDP per capita and urban population towards renewable energy consumption. However, the lack of causality from the other two variables should not be interpreted as a meaningless relationship. The causality test examines the presence of a linear relationship and does not consider any other forms of correlation. It is interesting to note that clean energy consumption did not cause any of the four explanatory variables. Due to the lack of endogeneity, using them as exogenous variables was an appropriate choice.

Since the study's time domain was not sufficiently large, employing a panel ARDL model was not feasible. Therefore, adding the lags of the dependent variable to the list of explanatory variables made the model's nature dynamic. Besides, based on the AIC and SBC information criteria, the most informative choice was the first lag. The results achieved by employing a GMM estimator led to a well-descriptive approximation with an adjusted R statistic of about 0.99, which was a significant outcome. Among the estimated variables, only the coefficient of the Log(FDI) was statistically insignificant at the 10 percent level, which is contradictory to the findings of Paramati et al. [28] and Kilicarslan [26]. However, as mentioned in analyzing the causality test results, it can be attributed to the possible non-linear relationship between those variables. Moreover, as was predicted, the RQI had a negative impact on the response variable. So, among the G-7 countries, a one percent increase in RQI will lead to a 0.22 percent decrease in the shares of renewable sources from primary energy. That means complicated decision-making processes, in general, harm renewable energy consumption levels. Nevertheless, it does not imply that a sharp decrease in RQI will lead to higher consumption. In fact, as with most aggregate variables, this variable should have a threshold effect. That means around the threshold value, the response variable will be maximized concerning that explanatory variable, but positioning in points higher or lower than the threshold level will decline the total effect. By the way, this result is contradictory to the finding of Rahman and Sultana [13].

The highest impact belonged to urbanization, with about a 1.26 percent increase in renewable energy shares for a one percent increment in the urban population (percentage of the total population). Since the technologies of green electricity, like photovoltaic panels and solar battery chargers, are accessible to most urban people, it seems the urbanization effect on clean energy consumption will gradually increase. This finding supports the results of Vo D. and Vo A. [31], Zhao and Zhang [33], and Asif et al. [36]. Finally, the GDP per capita had a slight but positive effect. As discussed before, the GDP and energy consumption are correlated, and mostly, there is a bidirectional causality between them. However, according to the estimated coefficients, it had a small impact on renewable energy, which was only a 0.06 percent increase for a one percent enhancement in GDP per capita. Nevertheless, since the population growth rates among the G-7 countries are almost less than one percent on average, increasing the GDP levels can promote its impact on renewable energy amounts through higher values for the GDP per capita. This finding is consistent with the conclusion of Rahman and Velayutham [24] and Fotourehchi [23] but not in the direction of the observation of Asif et al. [36] and Ocal and Aslan [21].

The residual diagnosis of the model showed a normal distribution and cross-sectional independence of innovations. The first-generation unit root tests revealed that the residuals were stationary, indicating that the model was cointegrated. This implies that the variables are in a long-run relationship, and therefore, the interpretations are meaningful. However, regarding FDI, while the estimated coefficient was not statistically significant, there is a possibility that the variable indirectly affects renewable energy consumption. For example, if an increase in FDI levels enhances total GDP, it could result in a promotion of renewable energy consumption. Thus, under this assumption, FDI affects the response variable through the channel of GDP. However, it should be noted that removing FDI from the model would result in poor estimation outcomes with only two significant coefficients and unstable residuals. Therefore, the presence of FDI as an explanatory variable is essential to establish a cointegrated relationship.

5. Conclusion and Policy Implications

Throughout the past 50 years, the global economy has faced numerous game-changing events, including several oil price shocks and the increasing disastrous side effects of global warming, such as vast forest fires, sea-level rise, and the disappearance of small islands. Each of these events has pushed the world's economy towards profound uncertainty and complicated financial decisions. Thus, the only way forward is to break humanity's addiction to fossil fuels and move towards a green economy by producing and consuming more energy from renewable sources. To this end, the present study attempted to investigate the most influential factors affecting renewable energy consumption by conducting a dynamic panel analysis among the G-7 countries, considering annual data from 1996 to 2018. A review of the mainstream economic literature indicated that four variables, GDP per capita, FDI, urban population, and the regulatory quality index (RQI), should be considered the crucial socioeconomic factors affecting renewable energy consumption trends.

Based on the outcomes of this research, urbanization has the most positive impact on the renewable energy consumption, followed by economic growth, while the RQI has the worst negative effect. The effect of FDI on the renewable energy is also found negative, which may be due to the fact that FDI is not appropriately channeled for green energy industries. For Japan, the urban population shapes more than 90 percent of the total citizens, and population growth rates follow a negative downward trend. Moreover, the country is not much welcoming to immigrants because most outsiders are not familiar with Japan's historical traditions and its complex social construction. Therefore, a significant increase in the urban population, at least in the near future, will not be feasible, and the urban population should be assumed constant parameter in the model. In this regard, without any fundamental structural change, turning the buildings and houses into environmentally friendly ones, developing small-size portable green electricity producers, and moving towards smart cities will be the only achievable solutions to enhance energy consumption from renewable sources. Since economic growth also promotes renewable energy consumption in the G-7 countries, appropriate measures and policies should be adopted and implemented for the sustainable economic growth in Japan.

Directing foreign direct investment (FDI) towards green energy infrastructure is a policy that can increase total GDP and ensure sustainable energy production from renewable resources. Fortunately, G-7 countries benefit from significant inflows of FDI that can boost energy production from clean sources. Adopting tax exemption or tax reduction laws for companies investing in renewable energies can potentially direct FDI towards those industries.

From citizens' point of view, an efficient government is one that stabilizes the economy at higher equilibrium (high level of GDP and aggregate consumption), keeps inflation at lower rates, and fights against corruption and environmental polluters. However, governments should be realistic and pragmatic, not populist. Banning polluting industries will decrease production levels and generally increase the need for new investments. In the case of a country like Canada, the petroleum industry is the economic engine, and restricting these activities will reduce GDP levels and, consequently, lead to a cut in social welfare.

In Germany, the country has always been one of the main destinations for immigrants, especially from the least developed countries. Moreover, in recent years, particularly during former Chancellor Merkel's era, Germany has been a welcoming host for immigrants from all around the world. Germany is a fully industrialized country with a substantial volume of manufactured products with high technology compared to agricultural commodities. An increase in the number of incoming people has almost directly correlated to an increment in the urban population. An incumbent government that follows the policies of right-wing and anti-immigrant parties would harm the process and, by slowing down the urbanization trends, decrease renewable energy consumption. The situation in the USA is quite different from Germany. Most immigrants, especially from Central and South America, have been employed in the southern states to work in the agricultural section. Unlike Germany, the USA is one of the world's largest agricultural producers, and thus, unskilled workers from least-developed countries will be directed to rural districts. As a result, an increase in incoming immigrants will decrease the urban population ratio to the total population, and hence, renewable energy consumption will decline. To stop this damaging process, removing programs like the diversity visa (DV) lottery and promoting the security of the country's border, specifically with Mexico, may stop the increasing trend in the rural population in favor of urban ones.

The conditions in the UK and France are almost similar. Both countries have mild immigration policies, which have stabilized incoming people flows. However, the governments in both countries do not have enough legal authority. That means, in most cases, the parliament and NGOs have restricted the government's performance and turned it into an inefficient bureaucracy. This process has brought them a high level of RQI but has reduced the total renewable energy consumption. A cost-benefit analysis can determine if the advantages of more democratization outperform its disadvantages; however, that analysis was beyond the scope of this study. Consequently, a powerful government with more authority can reduce RQI slightly in favor of an increase in overall renewable energy consumption. Governments should always insist on the fact that "the belief of the majority in a wrong statement will not turn it into a correct proposition." Hence, although the higher value of RQI obviously is an important criterion affecting voters' decisions, the government should focus on societal benefits more than just reelection. As a result, keeping the RQI within a reasonable range will bring several advantages. However, as mentioned earlier, the first step should be analyzing the possible threshold effect of RQI on energy consumption and then trying to push the variable towards its threshold value.

In this study, we attempted to incorporate the effect of a crucial variable, the export quality index (EQI), which indicates the level of technological content in a country's exports. However, adding this variable violated the cointegration condition, making it infeasible to use. It is suggested that future studies include EQI in their models as it highly correlates with energy consumption and, more importantly, energy efficiency. Additionally, policy uncertainty is an important factor to consider due to the chaotic nature of world economics. Economic policy uncertainty (EPU) index is often used by researchers to measure this. Empirical studies such as Isik et al. [59] have proven the index's applicability in enhancing a model's explanatory power. However, we were unable to use the EPU variable due to missing data for some of our selected countries for some years. Hence, we suggest that future studies consider the effect of this index while analyzing renewable energy consumption.

Data Availability

All the financial and nonfinancial data used to support the findings of this study can be found through the available and free accessible websites (databases) as follows: (1) http://www.government.is/topics/business-and-industry/energy (Iceland Government); (2) http://www.data.worldbank.org (World Bank Database); (3) http://www.aljazeera.com/economy/2018/3/28/saudi-arabia-to-create-worlds-biggest-solar-power-firm (Aljazeera News Agency).

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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