

Article

The Impact of Oil Price on Transition toward Renewable Energy Consumption? Evidence from Russia

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Abstract: This research investigates the impact of oil price, income and carbon dioxide emissions on renewable energy consumption in Russia for the data period from 1990 to 2015, using the Vector Error Correction Models and the Canonical Cointegrating Regression method. This article is the only study conducting individual time-series analysis that emphasizes the effect of oil price on renewable energy consumption in the case of Russia. The results of empirical analysis conclude that oil price affects renewable energy consumption negatively. The negative oil price effects on renewable energy use can be interpreted as a sign of issue that stems from higher oil prices and slows the transition from conventional to renewable energy sources. Additionally, we found that there is a positive and statistically significant influence of real GDP per capita as a proxy of income on renewable energy consumption, whereas the carbon dioxide emissions have a negative and statistically insignificant influence on renewable energy consumption. Considering these empirical results, Russia, which has a significant share in energy production in the world, should focus on the use of renewable energy in order to maintain this superiority and its sustainability. The findings of this paper may be useful to policymakers and may help to contribute to existing literature for future research in the case of oil-exporting countries.

Keywords: income; renewable energy; oil price; VECM; CCR; Russia



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1. Introduction

All activities in nature take place by the courtesy of energy. Therefore, energy is an indispensable element of natural life. Unlike other beings, humans have succeeded in transforming fossil fuels into energy by using their intelligence and the opportunities offered by nature. In this way, the production has been based on fossil fuels for about two centuries. However, fossil fuels pollute the air because they contain high levels of carbon [1–4]. It is a known fact that the use of fossil fuels (coal, oil, and natural gas) causes global warming. Global warming causes more severe weather conditions, droughts, forest fires, rising sea levels, and floods, among other effects [5].

The use of some fossil fuels, such as natural gas, coal, and oil, currently meets most of the world's growing energy demand but is destined to run out relatively quickly. In this context, the necessity of alternative energy systems is of great importance in terms of sustainability [6,7]. Renewable energy plays a vital role in the sustainable development of a society today [8]. If we are to plan our future considering known energy sources, the only option is sustainable renewable energy sources. In this context, it will be of great benefit if renewable energies such as solar, wind, biomass, and water can be used in all sectors (industry, housing, and transportation) [9].

Renewable energy is defined as energy obtained from inexhaustible sources that generate low levels of greenhouse gas emissions [10]. The policy of increasing the share of renewable energy in countries around the world is high on the agenda. Several governments have set ambitious goals and have started establishing support programs aiming to facilitate the implementation of a market. The degree of success of these policies may differ among countries [11]. This difference may arise due to their relative position as an oil importer or exporter and their tax structure [12]. Another difference between oil importing and exporting countries is due to fluctuations in oil prices. An increase in oil prices may occur due to political events [13], global demand shocks [14], the appreciation of the US dollar [15], contraction in production [16], and an increase in costs [17]. In this context, while increasing oil prices will encourage more oil production in the exporting country, it will adversely affect renewable energy investments. In case of a decrease in oil prices, a similar process will be experienced for the importing country.

It is also possible to see the positive effect of high crude oil prices on the renewable energy sector through the improvement in the stock market performance of energy companies [18]. Studies [19–21] suggest that there is a positive relationship between the stock prices of renewable energy companies, and crude oil prices confirm this situation. The roots of this positive bond are that clean energy is often seen as a substitute for fossil fuel energy [18]. In this context, public spending aimed at gradually reducing dependence on fossil fuels and carbon dioxide emissions can be reduced when it provides the necessary incentives for those who want to invest in the renewable energy industry [22]. In addition, the use of renewable energy sources can be a strategy to reduce environmental degradation and import dependency, in particular. This will contribute to preventing the unwanted consequences of fluctuating oil prices in energy-dependent countries [23].

Renewable energy is commonly considered as an alternative for crude oil in both consumption and output of other energy sources, according to the literature. From this perspective, a positive link between oil prices and renewable energy demand is anticipated, because increasing oil prices would give incentives to firms and households to decrease their consumption, buy more energy-efficient goods, and switch from traditional to renewable energy [24]. In point of fact, high oil prices should encourage more investment in renewable energy sources. High oil prices by 2015 necessitated a less expensive alternative, although low oil prices were anticipated to decrease investment in alternative energy sources. Before the recent steep drop in oil prices, this theory was right. It is claimed that oil price instability is one of the causes for green energy's rising appeal as a means of declining oil dependency, making it vulnerable to price shocks. Although, declining oil dependency has become a major issue not only for oil-importing countries, but also for oil-exporting countries, especially after oil prices fell sharply between 2008 and 2014 [25]. When oil prices are higher, oil-exporting countries can take advantage of ample resources available to provide subsidies to domestic users, resulting in a rise in conventional energy consumption and a lack of motivation for producers and consumers to rely on alternative energy sources. During periods of high oil prices, though, it could be appropriate to invest oil revenues in renewable energy ventures and boost renewable energy use. In addition, oil-exporting countries should export oil products and encourage renewable energy use domestically, thus rising renewable energy use. On the other hand, higher oil prices deter the use of oil products and encourage the reliance on renewable sources, which could lead to a rise in renewable energy demand in oil-importing countries [26]. In the literature, it is possible to see some studies examining the impact of oil prices on renewable energy consumption in the case of both oil-exporting and oil-importing countries. These studies have approved the above-mentioned facts. For example, Sadorsky [27] for G7 countries, Salim and Rafiq [28] for China and Indonesia, Omri and Nguyen [29] for 64 countries, Deniz [25] for oil-exporting countries and Mukhtarov et al. [26] for Azerbaijan, and Mursheed and Tanha [30] for Bangladesh, India, Pakistan, and Sri Lanka, concluded a negative effect of oil price on renewable energy consumption. Moreover, Marques and Fuinhas [31] in the case of 24 European Union countries, Salim and Rafiq [28] in the case of Brazil, India,

Philippines, and Turkey, and Nguyen and Kakinaka [32] in the case of middle-income countries, found an insignificant effect of oil price on renewable energy consumption. As a result, country-specific studies are necessary to determine how renewable energy demand responds to oil prices. In light of the above, it is crucial to investigate how oil price fluctuation influences economies' efforts to shift from conventional to renewable energy consumption.

The influence of oil price on renewable energy use varies from country to country. Therefore, studies conducted in the country can make different contributions to the literature. As a result of the investigations, it was found that there was no such study in Russia, using country-specific time-series data. Therefore, the key goal of this article is to conduct a study for Russia, by investigating the impact of oil price on renewable energy consumption, utilizing Vector Error Correction Models (VECM) and Canonical Cointegrating Regression (CCR) techniques. The contributions of this paper are as follows: (a) it examined the relationship between renewable energy use and GDP per capita in Russia, which has not been studied before in an energy–income context and is a good example for similar oil-exporting countries, and (b) to the best of our investigation, this article is the first time-series analysis of the effect of oil prices on renewable energy consumption for Russia.

The structure of the paper is as follows: The background of renewable energy in Russia is described in Section 2. Section 3 provides a summary of the current literature. Section 4 contains a summary of the data as well as the methodology. Section 5 contains a discussion of the study's findings. The conclusion and policy implications are given in Section 6.

2. Energy and Renewable Energy in Russia

Russia has great potential in terms of energy production dependent on fossil fuels. However, fossil fuel resources, which are already limited during this period when the population and needs are growing rapidly, are declining every day. In addition, the damage caused by fossil fuels to the environment and human health has begun to be better understood. Realizing this situation, the global energy industry has entered a new structuring process in terms of obtaining energy and has turned to renewable energy sources as an alternative. However, Russia has not yet made satisfactory progress on this issue. What is the reason for Russia's slow progress, while many developed countries have made significant progress? The study was conducted to find the answer to this question, because Russia needs renewable energy policies in which it can compete on equal runs in the future in terms of the sustainability of its current energy superiority. In order to test the need for a sustainable energy policy, it is necessary to first examine the country's energy production and consumption.

As well as being the biggest global crude oil producer, Russia holds the second place in dry natural gas production too. In addition, Russia produces large quantities of coal. Russia's economy is highly reliant on hydrocarbons, with oil and gas revenues accounting for more than 33% of federal budget revenues [33]. The Figure 1 below shows the world ranking of Russia in terms of energy production.

Total consumption per capita in Russia reached 5.3 TEP in 2019. The average annual electricity consumption per person is about 6400 kWh. Total energy consumption increased by 2.6% year-on-year since 2015, to 768 in 2019. Previously, there was a slight decline between 2012 and 2015 (−1%/year) due to the economic slowdown and the recession in 2015. In 2019, Gas had the largest portion of consumption (54%), while the consumption of other fossil fuels such as oil (20%), coal (16%), nuclear (7%), hydro (2%), and biomass (1%) were lower [34]. The Figure 2 below depicts the annual changes in Russia's primary energy consumption as a percentage of the previous year.

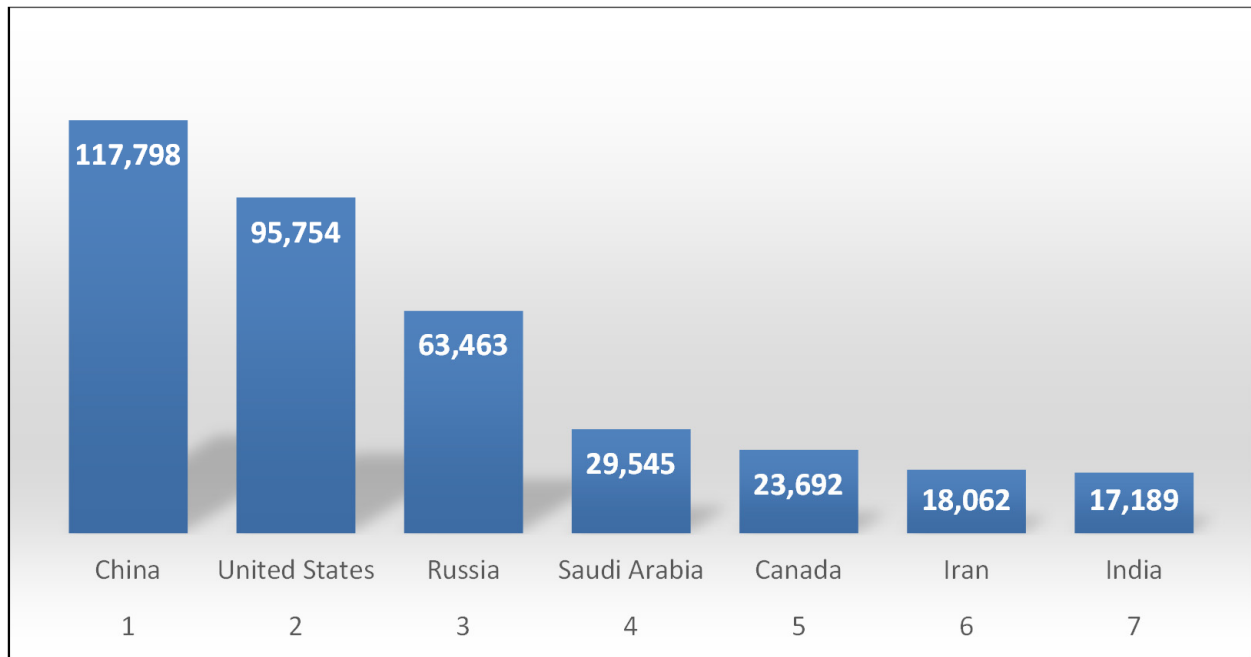


Figure 1. Total energy production. Source: [33].

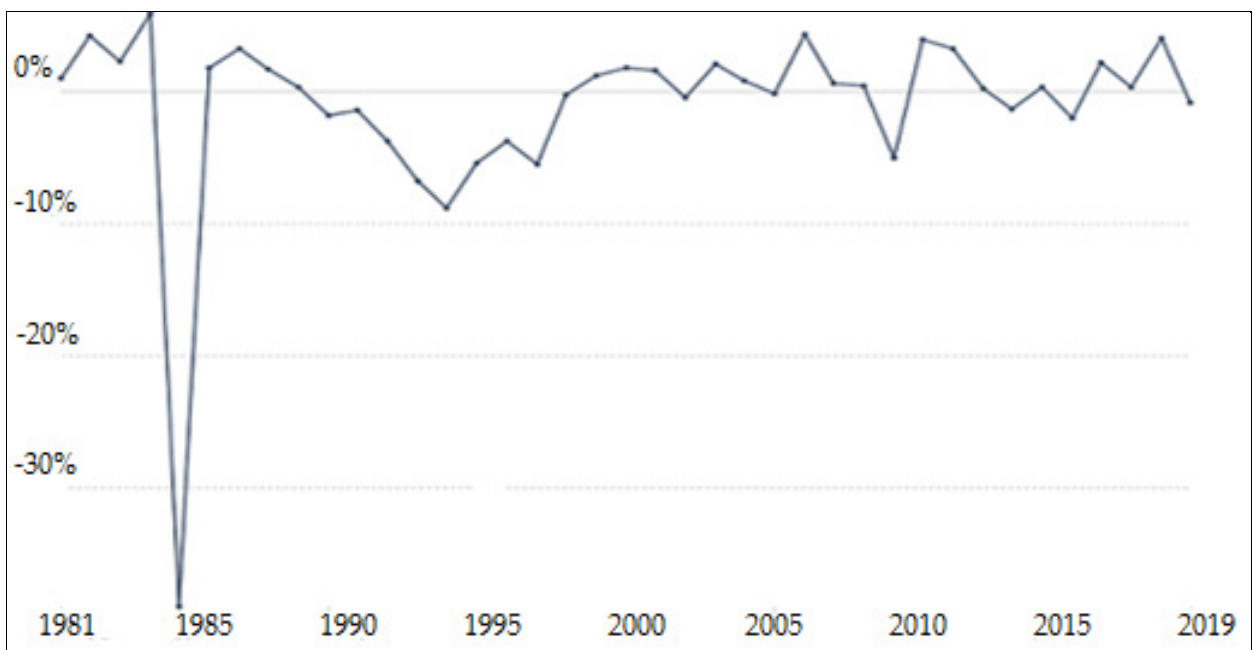


Figure 2. Annual change in Russia's primary energy consumption. Source: [35].

In the chart, the most important reason why Russia's energy consumption continued during the same period is the slow growth in the economy.

It is necessary to emphasize that most regions of Russia are insufficient in terms of energy, they need fuel and energy supplies. The solution to this regional energy problem is just like countries importing energy resources. Although there are rich natural gas reserves, about 50% of cities and about 35% of rural communities can use natural gas. Coal and petroleum products are mainly used in areas that lack natural gas. This causes environmental pollution [36]. Since carbon dioxide (CO₂) emissions are inversely proportional to energy consumption, CO₂ emissions from fossil fuels are mainly used as a proxy for energy efficiency. Russia's greenhouse gas emissions have declined by 21.5 percent

to 1467.6 million tons of CO₂ since 1991. The main reason for this is the decline in coal consumption and the increase in gas consumption [37].

In recent years, Russia's energy sector has undergone many reforms. All of these reforms help Russia have more liberalized electricity and natural gas markets and determine the prices closer to global market levels. Despite this, it falls behind other emerging countries with regard to efficient use of its energy [38].

As a traditional fossil fuel user, Russia is turning to alternative energy sources in order to improve the energy efficiency of its economy. Russia has the ability to expand the utilization of renewable energy by using its vast resources of various forms, covering bioenergy, geothermal, hydro, solar, and wind [39]. This capacity is fairly uniformly distributed across the country's 17.1 million km² surface area. The Caucasus Mountains, on the Mongolian border, and near Vladivostok are the most promising areas for solar energy production. The average annual daily amount of solar radiation falling on the surface at an angle equal to the latitude ranges in these areas ranges from 4 to 5.5 kWh/m² per day [40]. Although Russia is one of the first countries to lead the improvement of alternative energy technologies worldwide, unfortunately, it has not been able to make the expected progress over time, instead taking the preferred path of improving fossil fuels and nuclear energy [41]. It is possible to see this situation more clearly in the Figure 3 below.

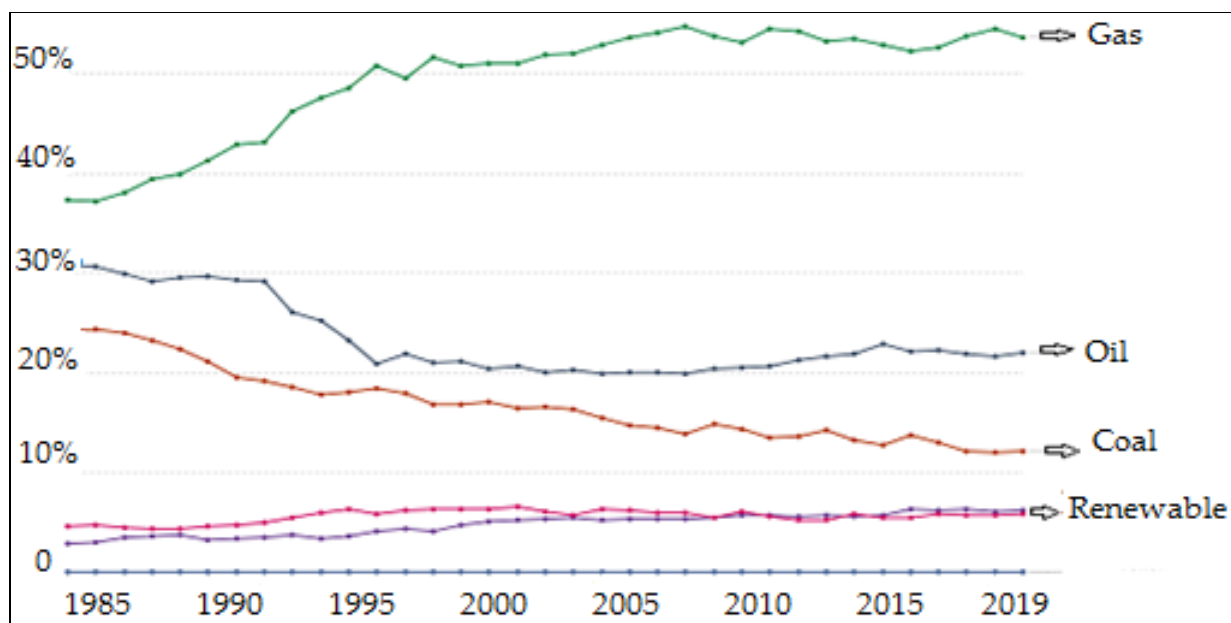


Figure 3. Share of energy consumption by source (quad Btu). Source: [35].

By 2035, renewable energy should account for 4.9 percent of Russia's overall primary energy consumption, up from 3.2 percent today. This covers Russia's plan to increase total solar photoelectric (PV), onshore wind, and geothermal capacity to 5.9 GW by 2024, which has been approved. Decree No. 449, which was passed in 2013 and provides a legal structure for the country's renewable energy capacity scheme, is the foundation for the development of renewable energy in Russia. The decree aims to promote the production of renewable energy, with a particular emphasis on wind and solar PV, as well as small-scale hydropower to a lesser degree. The law lays out the terms in which the country will participate in renewable energy markets [42]. Russia's energy policy emphasizes the stature of local production improvement, in the renewable energy sector. The state encourages potential investors to run production of high-tech components for power-generating facilities in Russia to improve competitive local technologies and production in the country [43]. The Figure 4 below shows the energy renewable technology mix in Russia.

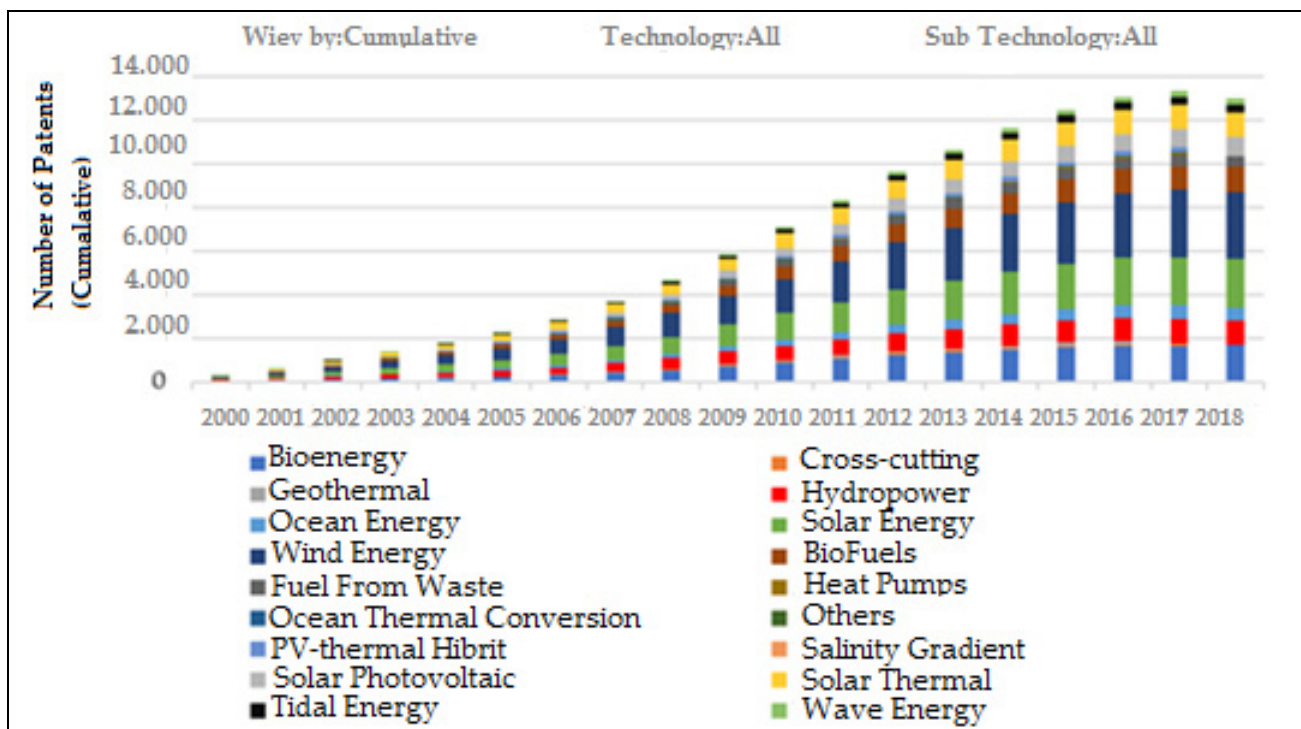


Figure 4. The energy technology mix in Russia. Source: [44].

Russia has the capacity to increase the use of all types of clean energy technology. The creation of a larger renewable energy sector in Russia would offer benefits for multiple sectors of the Russian economy, stimulating activity and job growth in the country [39].

3. Literature Review

The impacts of oil price on renewable energy consumption (REC) have been extensively examined, and varying results for different countries were obtained. Empirically, it is argued by many studies, such as Sadorsky [27] for G7 countries, Salim and Rafiq [28] for China and Indonesia, Omri and Nguyen [29] for 64 countries, Deniz [25] for oil-exporting countries, Mukhtarov et al. [26] for Azerbaijan, and Murshed and Tanha [30] for Bangladesh, India, Pakistan, and Sri Lanka, who revealed that oil price has adverse impact on REC. However, a positive effect from oil price to REC was reached by Omri and Nguyen [25], Apergis and Payne [45], Apergis and Payne [46], Azad et al. [47], Apergis and Payne [48], and Bamati and Roofi [49]. On the other hand, some recent empirical investigations, such as Marques and Fuinhas [31] in the case of 24 European Union countries, Tuzcu and Tuzcu [50] in the case of 7 OPEC members, and Nguyen and Kakinaka [32] in the case of middle-income countries, found statistically insignificant effects of oil prices on REC. In addition, Brini et al. [51] found an absence of cointegration relationship between oil price in Tunisia and REC, while Alege [52] found the existence of a cointegration link between used variables in 40 Sub-Saharan African countries. Table 1 summarizes the related literature.

Table 1. An overview of the empirical research.

Study	Period	Country(s)	Method(s)	Result (Impact of Oil Price on REC)
Sadorsky [27]	1980–2005	G7 countries	Panel FMOLS and DOLS	Negative
Marques and Fuinhas [31]	1990–2006	24 European Union countries	GMM	Insignificant impact
Salim and Rafiq [28]	1980–2006	6 emerging economies	Panel FMOLS, Panel DOLS, and Panel ARDL	- Insignificant effect for Brazil, India, Philippines, and Turkey - Negative for China and Indonesia
Payne [53]	1949–2009	USA	Toda-Yamamoto causality test	No causality between REC and real oil prices
Apergis and Payne [45]	1980–2011	25 OECD countries	Panel cointegration Model	Positive
Apergis and Payne [46]	1980–2010	7 Central American countries	Panel VECM	Positive
Tuzcu and Tuzcu [50]	1985–2007	7 OPEC members	Panel data techniques	There is no statistically significant impact of oil price on REC
Azad et al. [47]	1990–2011	Australia	GMM	Positive
Omri and Nguyen [29]	1990–2011	64 countries	Dynamic system-GMM panel model	Negative
Omri and Nguyen [24]	1990–2011	64 countries	Pooled OLS, Panel Fixed and Random Effects	Positive
Apergis and Payne [48]	1980–2010	11 South American	Panel FMOLS	Positive
Brini et al. [51]	1980–2011	Tunisia	Granger causality test and ARDL	- A unidirectional relationship from oil price to REC - No cointegration relationship
Alege [52]	2001–2014	40 countries in Sub-Saharan African countries	Panel cointegration and the pair-wise Granger causality	- Existence of cointegration relationship - Absence of causality
Troster et al. [12]	1989–2016	USA	Granger-causality test	No causality between oil prices and REC
Deniz [25]	1995–2014	GMM and Panel VAR	Oil importing and exporting countries	- Positive for oil-importing countries - Negative for oil-exporting countries
Nguyen and Kakinaka [32]	1990–2013	107 countries	Panel data method	- Positive effect for low- and high-income countries - Insignificant negative effect for middle-income countries
Ji and Zhang [54]	1992–2013	China	VAR	Oil prices explained about 20% of the total variations in REC
Bamati and Roofi [49]	1990–2015	Panel of 25 countries	Panel GLS	Positive
Mukhtarov et al. [26]	1992–2015	Azerbaijan	STSM	Negative
Murshed and Tanha [30]	1990–2018	Bangladesh, India, Pakistan, and Sri Lanka	Panel DOLS and FMOLS	Negative

4. Model and Data

4.1. Functional Specification and Data

Based on Mukhtarov et al. [26], the functional specification in this paper can be expressed as below:

$$\ln REC_t = \beta_0 + \beta_1 \ln OP_t + \beta_2 \ln GDP_t + \beta_3 \ln CO_{2,t} + \varepsilon_t \quad (1)$$

where, REC_t is renewable energy consumption, OP_t is oil price, GDP_t is income proxied by real GDP per capita, $CO_{2,t}$ is carbon dioxide emissions per capita, and ε_t is an error term.

In this paper, we use annual data from 1990 to 2015 for the renewable energy consumption, oil price, income, and CO_2 emissions. Our dependent variable is renewable energy consumption (REC). It is expressed by renewable energy consumption as a percentage of total final energy consumption. The oil price (OP) is expressed by US dollars per barrel, which is our main independent variable. The income (GDP) is expressed by real GDP per capita (2010 US dollars). CO_2 emissions per capita is expressed in kilotons (kt) of carbon dioxide. The REC, GDP, and CO_2 emissions data are compiled from the World Bank database [55]. The data for OP was provided from the Federal Reserve Bank of St. Louis [56]. For empirical analyses, we converted all variables to logarithmic form.

4.2. Methodology

In the current article, the effect of oil price, GDP per capita, and CO_2 emissions on renewable energy consumption was estimated utilizing the VECM method. In an initial step, the Augmented Dickey Fuller unit root (ADF) [57], Phillips–Perron (PP) [58], and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) [59] tests were applied for determining non-stationarity features of used variables.

In the next step, if the variables' orders of integration are the same, the cointegration test will be employed to determine if they are cointegrated. Therefore, the Johansen test [60,61] was applied to test the cointegration relationship.

Eventually, after verifying the presence of cointegration link between the variables, we examined the long-term relationship between the variables utilizing the Vector Error Correction Model (VECM). In addition, we employed the Canonical Cointegrating Regression (CCR) test in order to obtain more robust results.

We do not explain the methods described above since they are commonly used in many studies. The detailed information can be obtained in the studies by Dickey and Fuller [57], Phillips and Perron [58], Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) [59], Johansen [60], Johansen and Juselius [61], and Park [62].

5. Empirical Results and Discussion

Employing the ADF, PP, and KPSS unit root tests, the stationarity properties of the variables were first checked. Table 2 summarizes the results of the ADF, PP, and KPSS. As shown by the unit root tests, all of the variables are non-stationary at their level, but they are stationary at first difference. As a result, we can employ the cointegration test.

Table 2. Unit root tests' results.

Variable	The ADF Test				The PP Test		The KPSS Test	
	Level	k	First Difference	k	Level	First Difference	Level	First Difference
REC	−2.4206	0	−7.7681 ***	0	−2.4206	−12.710 ***	0.7530	0.0649 ***
OP	−1.2838	0	−3.6249 **	0	−1.2358	−3.6253 **	0.7814	0.1435 ***
GDP	−0.9593	2	−3.5340 **	1	0.6576	−3.5223 **	0.8829	0.3339 ***
CO ₂	1.4275	0	−3.9772 ***	0	−1.4375	−4.0353 ***	0.7490	0.3994 **

Notes: ADF, PP, and KPSS accordingly refer to the Augmented Dickey–Fuller, Phillips–Perron, and Kwiatkowski, Phillips, Schmidt, Shin tests. Two is determined as maximum lag order and optimal lag order (k) is selected according to Akaike criterion in the ADF test; **, and *** accordingly refer to rejection of the null hypothesis at 10%, 5%, and 1% significance levels. The critical values are compiled from MacKinnon [63] and Kwiatkowski, Phillips, Schmidt, and Shin [59].

In order to use the Johansen cointegration technique, the optimum lag number must first be determined. A Vector Auto Regressive (VAR) model with REC, OP, GDP, and CO₂ was initially defined with an arbitrarily designated lag interval, and a determination test of lag interval was employed to the residuals in order to define the optimal lag interval in the sample. The outcomes of this test are depicted in Table 3. All lag selection criteria revealed that a lag of order two is optimal in this study.

Table 3. Lag interval tests.

Lag	Information Criteria					
	LogL	LR	FPE	AIC	SC	HQ
0	73.27637	NA	4.03×10^{-8}	-5.676206	-5.281251	-5.576876
1	144.5878	105.4169	3.45×10^{-10}	-10.48590	-9.301035	-10.18791
2	174.1625	33.43225 *	1.29×10^{-10} *	-11.66631 *	-9.691533 *	-11.16966 *
3	188.9660	11.58532	2.45×10^{-10}	-11.56226	-8.797577	-10.86695

* Indicates lag order selected by the criterion.

The VAR has worthy characteristics, according to Panels A through D in Table 4, since it becomes stable, the residuals do not show a serial correlation or heteroscedasticity problem, and they have normal distribution.

Table 4. The residual diagnostics of VAR and cointegration tests' results.

Panel A: LM Test				Panel E: Johansen Cointegration Rank Test (Trace)				
Lags	LM-Statistic	p-Value		Null Hypothesis	Eigenvalue	Trace Statistics	0.05 Critical Value	p-Value
1	15.5047	0.488		None	0.77816	71.0141	63.8761	0.011
2	19.7932	0.229		At most 1	0.59520	36.3802	42.9152	0.192
3	13.1405	0.662		At most 2	0.40299	15.5798	25.8721	0.526
4	23.1438	0.109		At most 3	0.14918	3.71583	12.5179	0.782
Panel B: Normality Test ^b				Panel F: Johansen Cointegration Rank Test (Maximum Eigenvalue)				
Statistic	χ^2	d.f.	p-value	Null hypothesis	Eigenvalue	Max-Eigen Statistic	0.05 Critical value	p-value
Jarque-Bera	5.975	8	0.650	None	0.77816	34.6338	32.1183	0.024
				At most 1	0.59520	20.8004	25.8232	0.200
				At most 2	0.40299	11.8640	19.3870	0.427
				At most 3	0.14918	3.71583	12.5179	0.782
Panel C: Heteroscedasticity Test ^c								
White Statistic	χ^2	d.f.	p-value					
	172.84	170	0.424					
Panel D: Stability Test ^d								
Modulus	Root							
0.80274	0.46076 - 0.65733i							
0.80274	0.46076 + 0.65733i							
0.49499	-0.06458 - 0.49076i							
0.49499	-0.06458 + 0.49076i							

Notes: ^a The null hypothesis of the LM Test shows no serial correlation in residuals at second order lag. ^b The Normality Test denotes the normal distribution of residuals. ^c The null hypothesis of White Heteroscedasticity Test asserts that the residuals have heteroscedasticity problems. ^d The results of the VAR stability test show that all of the characteristic polynomial's roots are contained within the unit circle. χ^2 denotes the Chi-square distribution. d.f. is degrees of freedom.

The cointegration relationship was tested using the Johansen cointegration test. Panels E and F of Table 4 present the results of the Johansen cointegration test. The trace and max-eigenvalue test statistics show that the variables have a cointegration relationship. As a result, we conclude that the variables have a cointegrating relationship.

Lastly, we applied the VECM and CCR methods to evaluate coefficients of the long-run relationship among the variables after verifying the existence of cointegration among the variables. The first-best solution would be to employ the VECM method if there is one cointegration relationship between the variables. Additionally, the VECM residuals were also applied to diagnostic tests. The outcomes of VECM and CCR are depicted in Table 5.

Table 5. Long-run coefficients from the VECM method.

Methods	OP	GDP	CO ₂
	Coef. (t-Stat.)	Coef. (t-Stat.)	Coef. (t-Stat.)
VECM	−0.43 (−2.87) **	0.99 (2.77) **	−0.66 (−1.54)
CCR	−0.14 (−5.83) ***	0.20 (3.59) ***	−0.01 (−0.44)
Residuals diagnostics tests results of VECM			
LM_{SC}		5.73 (0.991)	
χ^2_{HETR}		104.7 (0.14)	
JB_N		192.7 (0.431)	

Notes: REC_t is the dependent variable; ***, ** refer to significance levels at 1%, 5%, and 10%; LM_{SC} = Lagrange multiplier statistic for serial correlation test; χ^2_{HETR} = Chi-squared statistic of heteroscedasticity test; JB_N = Jarque-Bera statistic for normality test. Probabilities are given in brackets.

As shown in Table 5, VECM residuals have no serial correlation, instability, or heteroscedasticity problems. As a result, the residuals of the evaluated specifications meet the requirements of residuals diagnostics tests, indicating the estimation results' robustness.

As shown in Table 5, the long-run coefficients of two methods are statistically significant and very similar to each other in terms of both significance and sign. As mentioned in the Methodology Section, the results of the VECM model, which are presented in the first row of Table 5, are given precedence. The VECM results reveal that OP has a statistically significant and negative influence on REC. The results indicate that a 1% OP per capita leads to a decline in REC by 0.43%. This implies that a rise in oil prices reduces renewable energy consumption. Our outcomes are in line with outcomes of Sadorsky [34] in the case of G7 countries, Salim and Rafiq [35] in the case of China and Indonesia, Omri and Nguyen [36] in the case of 64 countries, Deniz [37] in the case of oil-exporting countries, and Mukhtarov et al. [38] in the case of Azerbaijan. Additionally, we found that there is a positive and statistically significant effect of GDP on REC. This indicates that a 1% increase in real GDP per capita results in a 0.99% rise in REC. As shown by the positive impact of income on REC, Russia uses its rising revenues to transition to renewable energy sources. Our findings are consistent with the traditional expectation. In addition, CO₂ emissions have a negative and statistically insignificant impact on REC, according to the results.

6. Conclusions

The current article investigated the effects of oil price, income, and CO₂ on renewable energy consumption. The ADF, PP and KPSS unit root tests revealed that all of the chosen economic indicators have the same integration order, being one. As a result, the existence of a cointegration nexus among the variables was tested. The Johansen cointegration test showed the presence of long-run co-movement. The VECM and CCR methods were applied in the evaluation of a long-run relationship.

For the studied period, empirical findings revealed that income has a positive effect on REC, whereas the oil price has a negative influence on REC in Russia. The adverse effect of oil price on REC implies that Russia goes on to be plagued by high oil prices, which is decelerating the shifting process from conventional to renewable energy sources. In addition, the findings show that CO₂ emissions have a negative and statistically insignificant impact on renewable energy consumption. The negative insignificant effect of CO₂ emissions on renewable energy use also approves the country's relative disinclination to use alternative energy, as increasing CO₂ emissions does not drive the country to formulate a more environmentally friendly policy. According to our results, we can say that the policymakers in Russia and similar oil-exporting countries should increase the portion of renewable energy in the total energy use portfolio for diversifying the economy and achieving sustainable economic development targets. It worth to note that given the limited supply of oil and reducing the impact of fossil fuels on environmental degradation, the production and use of renewable energy should be prioritized.

Russia has great potential in terms of renewable energy sources as well as fossil fuels. Almost one third of its national income is from export revenues related to fossil fuels. However, both the depletion of fossil fuels and the decline in demand around the world indicate that Russia will lose this advantage in the future. From this point of view, Russia should implement projects that will allow it to use renewable energy sources as soon as possible. In this context, it is of great importance to carry out comprehensive and efficient studies in areas such as solar, wind, geothermal, and biomass.

An important factor in preventing the expansion of Russia's renewable energy production is the unfavorable climate and landforms. Therefore, efficient renewable energy production with traditional equipment cannot be achieved. Therefore, appropriate technological infrastructure investments should be given priority. It will also encourage the expansion of renewable energy facilities, and the implementation of incentive policies such as tax relief, land allocation, low interest, and long-term credit facilities will be of great benefit.

It is possible to list the benefits of the obtained results in a global context as follows: Harmful gases generated by the use of fossil fuels have brought about the problem of global warming and related climate change. The most important step to be taken to combat climate change is to reduce the use of fossil fuels. In this context, a country with a significant share on a global scale, such as Russia, would be of great benefit in the fight against climate change if it gave up fossil fuel production and turned to renewable resources. At the same time, if Russia, which has a great potential in terms of renewable energy sources, will take a step in this regard, just as in fossil fuel production, it will have a global share in renewable energy production. This will serve as a model for other oil-exporting countries.

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Nomenclatures:

ADF	Augmented Dickey-Fuller
ARDL	Autoregressive Distributed Lags Bounds Testing
BRICS	Brazil, Russia, India, China, South Africa
CO ₂	Carbon Dioxide
CPI	Consumer Price Index
DOLS	Dynamic Ordinary Least Squares Technique
EU	European Union
FMOLS	Fully Modified Ordinary Least Squares Technique
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product per capita
GMM	Generalized Method of Moments
GLS	Generalized Least Squares
REC	Renewable Energy Consumption
OP	Oil Price
OPEC	The Organization of the Petroleum-Exporting Countries
OECD	The Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
STSM	The Structural Time Series Modeling
TVC	Time-Varying Coefficient Cointegration Approach
VECM	Vector Error Correction Method
VAR	Vector Autoregression

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