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Investigating Factors Affecting Renewable and Nonrenewable Electricity Generation in Iran

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ABSTRACT

This study identifies key elements that facilitate the transition of power generation from non-renewable to renewable sources. Annual data from 1977 to 2018 and an autoregressive distributed lag model are used in the study. The gross domestic product, industrialization, urbanization, fuel, and power prices, as well as the dollar exchange rate, are employed as independent variables. The study takes the Iran-Iraq War and nuclear sanctions into account. The findings show that, in the short run, all variables—aside from the exchange rate—have an impact on the generation of electricity from renewable sources. Only natural gas prices, industrialization, and gross domestic product are effective in the short run, for power generation from non-renewable energies. In the long run, all variables, with the exception of electricity price, are effective in producing power from renewable sources, and all variables, with the exception of fuel prices and industrialization, are effective in producing electricity from non-renewable sources. The findings also indicate that nuclear sanctions have a detrimental impact on the production of electricity from renewable sources and a beneficial impact on the production of electricity from non-renewable sources.

Keywords: Electricity Generation, Power Production, Renewable Energies, Non-Renewable Energies, ARDL, Natural Gas
JEL Classifcation: Q43

1. INTRODUCTION

Achieving sustainable development is currently one of the top priorities for nations. By increasing the density of carbon dioxide and other pollutants, the use of fossil fuels as a non-renewable source of energy has a severe impact on the environment and the quality of life for humans. It aids in ending the crisis of running out of the non-renewable fossil resources that nature has produced for millions of years. Clean, contemporary, efficient, safe, and sustainable energies are offered by renewable sources, which encourages the integration of economic activity with environmental concerns. According to (Adebayo, 2023a), the use of renewable energy, economic complexity, and financial risk all contribute to improvements in ecological quality, but the use of non-renewable energy puts that quality in danger in BRICS countries. Similar findings were found by (Adebayo et al., 2023). (Adebayo et al., 2023) also discovered similar results in MINT. demonstrating the environmental benefits of renewable energy sources. In a sustainable development model, where the environment and economic growth are two complementing variables that affect the balance of ecological and economic activity, renewable energies assist the economy in moving closer to this goal (Resch et al., 2008). One of the key energies necessary for achieving sustainable development goals is electricity. Nine out of ten people on the planet have access to electricity, making this one of the biggest and most diverse industrial sectors in the world (United Nations, 2019; Breeze, 2017). Although using electricity is a clean energy source, producing it can have a negative impact on the environment if its fuel source is non-renewable. Depending on their location, power plants can run on a variety of non-renewable energies, such as diesel or petrol, or renewable energies, such as wind, water, or solar. The extensive usage of electricity, however, brings attention to its importance for green economic development and sustainable development. (Adebayo, 2023b; Adebayo et al., 2023) demonstrated that environmental degradation is a direct result of both economic expansion and the consumption of natural resources. In this study, the variables influencing Iran's generation of electricity from renewable and non-renewable sources are identified.

Due to severe air pollution problems, Iran places particular emphasis on adopting clean energy (Razmi et al., 2020; Renewable Energy and Energy Efficiency Organization, 2020). The Middle East and North Africa produce twice as much carbon dioxide as the typical region globally, according to the World Economic Forum (2019), since they are rich in fossil fuel resources and heavily rely on oil and gas for 92% of their primary energy needs. Iran is one of the few nations with legislation restricting air pollution, nevertheless. Iran has long-term goals to raise environmental standards. In Iran, the Renewable Energy and Electricity Efficiency Organization was established more than 20 years ago, and the Environmental Protection Organization was established about 50 years ago. The objective of these institutions is to develop the legal framework for clean production while raising public awareness of the value of readily accessible clean energy sources (Renewable Energy and Energy Efficiency Organization, 2020). The shift from traditional to modern energy has received significant attention in Iran's 5-year development plans (Alookandeh and Vaez-Zadeh, 2019). This study looks at the important variables that affect the electricity generated from renewable and non-renewable sources. In order to achieve this goal, two models for the generation of power from renewable and non-renewable sources have been estimated. As a result, policymakers may now create an effective plan for the switch from non-renewable to renewable sources.

Various economic factors, including economic growth, urbanization, electricity consumption, industrialization, exchange rate, fuel prices, and electricity prices, are shown in the literature review to have an impact on electricity generation. While currency rates, fuel costs, and power prices have an impact on electricity supply by changing the cost of producing electricity, economic growth, urbanization, and industrialization can affect electricity generation by increasing electricity demand (Oh and Lee, 2004; Lee and Chang, 2008; Kilic and Özdemir, 2018; Faisal et al., 2018; Jones, 1991; Tran et al., 2022). The greater population density in urban regions results in more industrial, commercial, and residential applications, therefore, demand for electricity rises due to urbanization and industrialization (Faisal et al., 2018) In Iran, the exchange rate has a significant impact on the price of producing energy and can affect producers' costs for goods and services (Rokhsari et al., 2022). Energy consumption has an inverse relationship with price, so a rise in energy prices generally results in a decline in consumption, which, if other inputs remain constant, also results in a decline in production (Razmi et al., 2022). However, if the price of one of the energy carriers, such as oil, rises more than the price of other carriers, some of the decrease in its consumption will be offset by using other carriers in its place (Dunkerley, 2016). It should be emphasized that factors impacting electricity generation have not received much attention, and the majority of studies have focused on the aforementioned elements in terms of overall energy production or consumption (Shaheen et al., 2020; Pan et al., 2019; Zheng and Walsh, 2019; Ayinde et al., 2019). In contrast, very few studies have looked at the production or consumption of electricity. Economic growth and GDP are the most well-known variables considered in different studies. Yoo and Kim (2006) demonstrated how, throughout time, the economic growth of Indonesia had an impact on energy production. However, Wu et al. (2019) found no evidence of a causal link between the electrical sector and economic growth in China, India, or the US. According to Lin and Wang's 2019 research, there is a link between power use and economic growth. (Atems and Hotaling, 2018; Marques et al., 2016b; Nathaniel and Bekun, 2020; Villanthenkodath and Mohammed, 2022) examined the inverse relationship between electricity generation and economic growth. Economic growth, urbanization, and industrial structure have been shown by Steenhof and Fulton (2007) to have an impact on electricity production. In a related study for Bangladesh, Shahbaz et al. (2014) examined the connection between industrialization, electrical consumption, and CO_2 emissions and discovered that industrialization can both boost electricity output and CO_2 generation. Ali et al. (2020) discovered a one-way causal relationship between urbanization and energy usage in Nigeria. Gregori and Tiwari (2020) and Liu et al. (2020) came to the same conclusion for China. The cost of electricity and alternative fuels may modify how power is produced. For instance, a study conducted in China (Lin and Chen, 2019) found that raising the price of electricity will, in the long run, boost the development of renewable energy sources there. However, Kwon et al. (2016) found that increasing electricity costs can be a barrier to South Korean electricity demand and output. Middle Eastern nations are extremely dependent on changes in fossil fuel prices as a result of the Middle East's availability of fossil fuels. The influence of fossil fuel costs on the generation of electricity from renewable and non-renewable sources must thus be studied in this research. According to a study conducted for Mexico, the price of fossil fuels has a positive short-term impact on power production (Bernal et al., 2019); however, Nakajima and Hamori (2012) showed that the price of fossil fuels has no impact on electricity production. However, it had an impact on the price of Japan's electricity production. Energy costs have been shown by Owoeye et al. (2020) and Li and Leung (2021) to have positive effects on the consumption of electricity. According to Kasap et al. (2020), using coal can improve Turkey's electricity efficiency. A similar conclusion was obtained concerning Spain by Munoz and Dickey (2009), who found that variations in the dollar price had an impact on the security of Spain's electrical supply and that exchange rate fluctuations affected electricity prices.

Electricity generation from non-renewable energies is calculated as the sum of electricity production by powerhouses whose fuels are natural gas, gasoline, diesel, and mixed non-renewable fuels. Electricity generation from renewable energies is the sum of electricity produced by powerhouses whose fuels are solar, wind, nuclear, and biogas. This research considers several factors as independent variables, including GDP, fuel prices, electricity prices, urbanization, industrialization, and the dollar exchange rate. It also considers the effects of war and sanctions on these two types of electricity generation. According to Becker and Fischer (2013), Sadeghi and Larimian (2018), and Le and Hoang (2021), sanctions can be an obstacle for investors since they need to invest in a secure environment.

This research investigates effective factors that affect electricity generation from renewable and non-renewable energies. To reach this goal, the research uses ARDL and the following factors: GDP, industrialization, urbanization, prices of fuel and electricity, and the dollar exchange rate. Notably, there aren't many aspects that affect electricity generation taken into account. The majority of studies in related publications have looked into the aspects that affect total energy consumption, but there are still a lot of economic considerations that can be made about electricity generation. This study makes an attempt to close the gap by carefully taking into account important aspects of electricity generation. Furthermore, this research is the first to take both renewable and non-renewable energy generation into account, to the authors' knowledge. This research assists policymakers in identifying key elements that can improve the consumption of renewable energy.

The remainder of the paper is as follows, section 2 explains data and methodology, section 3 discusses empirical results, and section 4 is dedicated to conclusion and policy implications.

2. DATA AND METHODOLOGY

This research employs the autoregressive distributed lagged (ARDL) model (Pesaran et al., 2001) to investigate effective factors affecting electricity generation from renewable and non-renewable energies in Iran. This research uses ARDL methodology to decompose the effective factors in the short- and long-run, like similar studies about electricity consumption and production (Marques et al., 2016a; Roespinoedji et al., 2019; Marques et al., 2019; Usama et al., 2020; Bento and Moutinho, 2016). Some advantages of the ARDL methodology have made this method superior to other methods. This methodology is not sensible to the order of integration of variables as long as the order of integration is not I(2) and Furthermore, the results of this method are more reliable in small samples (Odhiambo, 2009; Harris and Sollis, 2003). The error correction model (ECM) can be used to determine the speed of adjustment to long-run equilibrium.

$$\varnothing(L.P)Y_t = \sum_{i-1}^{k} b_i(L,q_i)X_{it} + c'w_t + u_t \tag{1}$$

Equation (1) represents an ARDL model in which Y_t is the dependent variable containing RE, electricity generation from renewable energies, and NONRE, electricity generation from non-renewable energies. X_{it} shows the independent variables, and w_t is the vector S × 1 that indicates the exogenous variables that are intercepts, dummy variables, time trends, and other exogenous variables. P represents dependent variable lags, and q shows independent variable lags. Independent variables are as follows: ex exchange rate or dollar price in domestic currency; PE; electricity price; PGA; gasoline price; PNG; natural gas price; IND; industrialization; URB; urbanization; GDP; gross domestic production; war; a dummy variable for the Iran-Iraq war; sanctions; and nuclear sanctions for the years 2009-2015.

The research employs a dollar rate because of its role in renewable energy investment in developing countries (Kim et al., 2017; Keeley and Matsumoto, 2018). The dollar rate plays a vital role in any investment in Iran. According to Sharifi-Renani and Mirfatah (2012), Iranian policymakers must lessen the dollar rate to improve investment. However, the Iranians have experienced situations like sanctions that affect the exchange rate. Wang et al. (2019) showed that economic sanctions highly influenced exchange rate volatility. Urbanization and industrialization are two factors that affect energy intensity and consumption (Yan, 2015). Electricity prices can affect energy supply by changing electricity demand (Kwon et al., 2016). Gasoline and natural gas are two main fuels for Iranian electricity production and can change electricity generation by affecting the cost of production (Fuss and Szolgayová, 2010). The research also employs two dummy variables for the Iran-Iraq war and nuclear sanctions as two important events for the Iranian economy. Sanctions create an uncertain environment for investments and people by affecting economic variables like inflation and exchange rates (Ghorbani Dastgerdi et al., 2018; Wang et al., 2019). The data were collected from the Iran Data Portal (2020).

$$\begin{aligned}\Delta RE_t &= a_0 + \sum_{i=1}^{p}\beta_{1i}\Delta RE_{t-i} + \sum_{j=1}^{q}\beta_{2i}\Delta EX_{t-j} + \sum_{j=1}^{q}\beta_{3i}\Delta GDP + \\ &\sum_{j=1}^{q}\beta_{4i}\Delta IND_{t-j} + \sum_{j=1}^{q}\beta_{5i}\Delta URB + \sum_{j=1}^{q}\beta_{6i}\Delta PE_{t-j} + \\ &\sum_{j=1}^{q}\beta_{7i}\Delta PNG_{t-j} + \sum_{j=1}^{q}\beta_{8i}\Delta PGA_{t-j} + a_1\Delta RE_{t-1} + \\ &\alpha_{21}GDP_{t-1} + \alpha_3 IND_{t-1} + \alpha_4 URB_{t-1} + \alpha_5 EX_{t-1} + \alpha_6 PE_{t-1} \\ &+\alpha_7 PNG_{t-1} + \alpha_8 PGA_{t-1} + \alpha_9 WAR + \alpha_{10} SANCTION + \varepsilon_t\end{aligned} \tag{2}$$

Equation (2) shows ARDL when electricity generation from renewable energies plays the role of the dependent variable. The variable RE can be instituted by NONRE when the goal is to find effective factors for electricity generation by non-renewable energies. An optimum number of lags FOR dependent and independent variables is shown by p and q, respectively. Estimating the short- and long-run coefficients of ARDL requires testing the existence of long-run relationships between variables by using F-statistics and comparing the critical values of ARDL for the upper bound and lower bound. This test is valid if the F-statistics is greater than the upper bound critical value, which means rejecting the null hypothesis of no long-run relationship. Less than a lower-bound critical value means no long-run relationship. At the same time, there is uncertainty about the long-run relationship when the f-statistic is between the upper and lower bounds.

3. EMPIRICAL RESULTS

The research tests the stationary of the variables to satisfy the order of integration of the variables to be no more than 1. It is essential for ARDL methodology for the independent variables to be of order one or zero and the dependent variable to be of order one (Salisu and Isah, 2017; Akalpler and Hove, 2019). The ARDL methodology cannot be employed if a variable is of order 2.

3.1. Unit Root Test

Table 1 shows the results of the augmented Dickey-Fuller test (Dickey and Fuller, 1979) and the Phillips-Perron test (Phillips and Perron, 1988) for level and first difference variables. The results of two tests indicate all the variables are of order 1 except urbanization which is integrated of order zero. Therefore, the study proceeds with the ARDL with a mixed order of integrations and dependent variables of order one.

3.2. ARDL Cointegration Test

The next step for proceeding with the ARDL method is based on the existence of long-run relationships among variables. Table 2 indicates the presence of long-run relationships when electricity generation from renewable energies and electricity generation from non-renewable energies play the role of the dependent variable. In both states, F-statistics are greater than the upper bound critical value at a 5% significant level, which indicates the existence of long-run relationships.

Table 3 represents the results of the ARDL test in the short-run and long-run for two models when the dependent variables are electricity generation from renewable energies and electricity generation from non-renewable energies. The results indicate the exchange rate or dollar rate has no effect on electricity generation in the two models at a 5% significant level in the short run. At the same time, it significantly and negatively affects electricity generation from renewable energies in the long run. However, this effect on electricity generation from non-renewable energies is significantly positive in the long run. A unit increase in the dollar rate decreases electricity generation from renewable energies by 3.27 and increases electricity generation from non-renewable energies by 0.23. This result suggests positive changes in the dollar rate will make electricity generation from renewable energies more expensive. Therefore, this reduction can be compensated by increased electricity generation from cheaper non-renewable energies in a country like Iran. Electricity price only significantly affects electricity generation from renewable energies in the short run. Still, it has a positive and significant effect on electricity generation from non-renewable energies in both the short and long run. An increase in the price of electricity reduces electricity generation from renewable energies by 7.49 and increases electricity generation from non-renewable energies by 0.3 in the short run. The prices change electricity generation from non-renewable energies by 0.3 in the long run. These results suggest that electricity prices stimulate electricity generation from non-renewable rather than renewable energy. Gasoline price affects electricity generation from renewable energies in both the short-run and long-run while having no effect on electricity generation from non-renewable energies. A unit increase in gasoline price increases electricity generation from renewable energies by 2.54 in the short-run and 4.69 in the long run. At the same time, it is not significant in affecting electricity generation from non-renewable energies. These results indicate that a gasoline price is a good tool for stimulating electricity generation from renewable energies. An increase in gas price, as a fuel price for non-renewable electricity generation, affects electricity generation negatively from non-renewable energies both in the short and long run. This will increase renewable energy electricity generation in the short run. At the same time, the sign is negative in the long run, which may be due to the vital role of natural gas in the Iranian economy. Electricity generation from renewable energies increases by about 2.54 units by a unit rise in the price of natural gas. In contrast, electricity generation from non-renewable energies decreases by about 0.14 in response to the same change in the short run. In the long run, a unit increase in gas price significantly reduces electricity generation from renewable and non-renewable energies by 2.23 and 0.14, respectively. Industrialization significantly and positively affects renewable energy electricity generation in both the short and long run. At the same time, it has a significant

Table 1: Unit root test

Variable	ADF			Phillips-Perron		
	Intercept	Trend and Intercept	None	Intercept	Trend and Intercept	None
EX	2.18	−0.49	0.63	2.73	0.24	1.32
ΔEX	−3.29	−4.47	−2.85	−3.19	−3.62	−2.71
PE	4.01	0.54	2.52	4.30	0.95	1.57
ΔPE	−4.75	−5.86	−1.33	−4.74	−5.93	−4.15
PGA	3.54	2.91	−0.02	1.67	0.12	−0.73
ΔPGA	1.37	−5.54	1.89	−5.69	−6.29	−5.45
PNG	2.65	−1.86	−0.66	−0.60	−1.84	−0.42
ΔPNG	−6.25	−7.09	2.43	−6.28	−7.90	−6.01
GDP	1.04	−3.31	0.15	0.65	−3.69	0.37
ΔGDP	−4.31	−4.84	−4.08	−4.29	−4.85	−4.07
IND	4.24	2.49	−1.60	−0.98	−2.30	−1.06
ΔIND	1.47	−7.84	0.06	7.26	−7.16	−7.14
RE	−0.97	−2.29	−1.04	−0.81	−2.37	−1.05
ΔRE	−6.31	−6.33	−6.22	−7.15	−7.89	−6.47
URB	−3.66	−3.36	−3.56	−3.37	−3.64	−3.28
NONRE	4.25	−1.59	−0.02	3.90	−1.63	0.41
ΔNONRE	−2.37	−6.60	−0.58	−4.28	−6.60	−1.12

Δ denotes the first difference operator. ADF critical values at 5% for intercept, intercept and trend and none are respectively −2.93, −3.53 and −1.95 and Phillips-Perron test critical values at 5% level for intercept, intercept and trend and None are −2.93, −3.52 and −1.94 respectively. EX, exchange rate or dollar price in domestic currency, PE, electricity price, PGA, gasoline price, PNG, natural gas price, IND, industrialization, URB, urbanization, GDP, gross domestic production, RE, electricity generation from renewable energies, NONRE, electricity generation from non-renewable energies positive effect on non-renewable energy electricity generation in the short run. Urbanization is significantly effective for electricity generation from renewable energies in both the short and long run. Still, it is only effective for electricity generation from non-renewable energies in the long run. GDP has a positive and significant effect on electricity generation in the short and long run. Among dummy variables, the dummy variable for the Iran-Iraq war is not significant in any of the models. In contrast, the dummy variable for nuclear sanction is significant in all models. When power generation from renewable energies is the dependent variable, the coefficient of sanction is −2.11 in the short run and −2.27 in the long run. They both are significant. When the dependent variable is the amount of power produced from non-renewable energy sources, this coefficient is 0.23 for both the short and long term. The signs are negative for electricity generation from renewable energies in both the short and long run. At the same time, they are positive for electricity generation from non-renewable energies, indicating the strong effect of sanctions on renewable energy electricity generation. Therefore, sanctions would lead the country to generate electricity with non-renewable energies that need less investment. Using standardized variables enables the research to compare coefficients according to their values. Three variables, GDP, industrialization, and urbanization have a stronger effect on electricity generation from renewable energies. An increase in gasoline prices is also strong for leading electricity companies towards using renewable energies in both the short and long run. At the same time, this effect is negative in the long run for gas prices.

Table 2: Cointegration test - ARDL approach

Dependent variable	RE		NONRE
F-statistic	25.21		11.60524
A critical value lower bound		1.97	
A critical value lower bound		3.18	

Critical values are %5 significant level

Policymakers must understand that increasing the dollar rate decreases electricity generation from renewable energies. The coefficient of sanction has a negative effect on electricity generation, which shows that sanctioned Iranian projects are not secure enough for investors in renewable energies.

Table 4 displays the results of the diagnostic tests for serial correlation, normality, and heteroskedasticity of residuals: the Breusch-Godfrey serial correlation LM Test, Jarque-Bera, and Heteroskedasticity Test. They show that residual normality, serial correlation, and heteroscedasticity are not issues for the two models when the dependent variable is electricity generation from renewable energies and electricity generation from no renewable energies. The Breusch-Godfrey serial correlation LM Test result for power generation from renewable sources is 5.36, with a probability of 0.06, indicating that the null hypothesis of no serial correlation cannot be rejected at 5% level. When the dependent variable is the electricity generation using non-renewable energies, the result is 4.33 with a probability of 0.11. The null hypothesis of no serial correlation cannot be rejected because the probability is greater than five percent. Jarque-Bera test for the first model is 0.07 with probability of 0.97 and for the second model is 1.45 with probability of 0.48, indicating that none of the two models allows the null hypothesis of residual normality to be rejected. Heteroskedasticity test: ARCH is 24.08 for the model 1 and has a probability of 0.11 for the model 1 and it is 20.95 and has a probability of 0.13 for the model 2. Since the probabilities for both models are more than 5%, there are no issues with heteroscedasticity in the residuals of the two models. Figure 1 shows stability test of the two models. Since the inside line does not touch the outer lines, the stability tests in Figure 1 show that the models are stable.

Although there is no similar research considering the comprehensive factors that affect electricity generation from renewable and non-renewable energies, the results can be compared with related

Table 3: ARDL long run and short run results

Short run	Dependent independent	RE		NONRE	
		Coefficient	prob	Coefficient	prob
	EX	1.54 (0.73)	0.05	−0.11 (0.08)	0.21
	PE	−7.49 (1.12)	0.00	0.30 (0.15)	0.05
	PGA	2.55 (0.71)	0.00	−0.03 (0.08)	0.73
	PNG	2.54 (0.76)	0.00	−0.14 (0.06)	0.03
	IND	0.51 (0.22)	0.03	0.11 (0.03)	0.00
	URB	1.59 (0.63)	0.02	0.04 (0.05)	0.47
	GDP	4.56 (1.45)	0.01	0.38 (0.11)	0.00
	WAR	−0.07 (0.38)	0.85	0.07 (0.04)	0.12
	SANCTION	−2.11 (0.33)	0.00	0.23 (0.04)	0.00
	CointEq(-1)	−0.93 (0.10)	0.00	−0.99 (0.12)	0.00
Long run	EX	−3.27 (0.59)	0.00	0.23 (0.05)	0.00
	PE	−0.16 (1.52)	0.92	0.30 (0.13)	0.03
	PGA	4.69 (1.16)	0.00	−0.03 (0.08)	0.72
	PNG	−2.23 (0.99)	0.04	−0.14 (0.06)	0.03
	IND	1.18 (0.38)	0.01	−0.06 (0.04)	0.14
	URB	0.43 (0.18)	0.03	0.17 (0.02)	0.00
	GDP	1.49 (0.64)	0.03	0.73 (0.07)	0.00
	WAR	−0.08 (0.41)	0.85	0.07 (0.04)	0.13
	SANCTION	−2.27 (0.25)	0.00	0.23 (0.03)	0.00

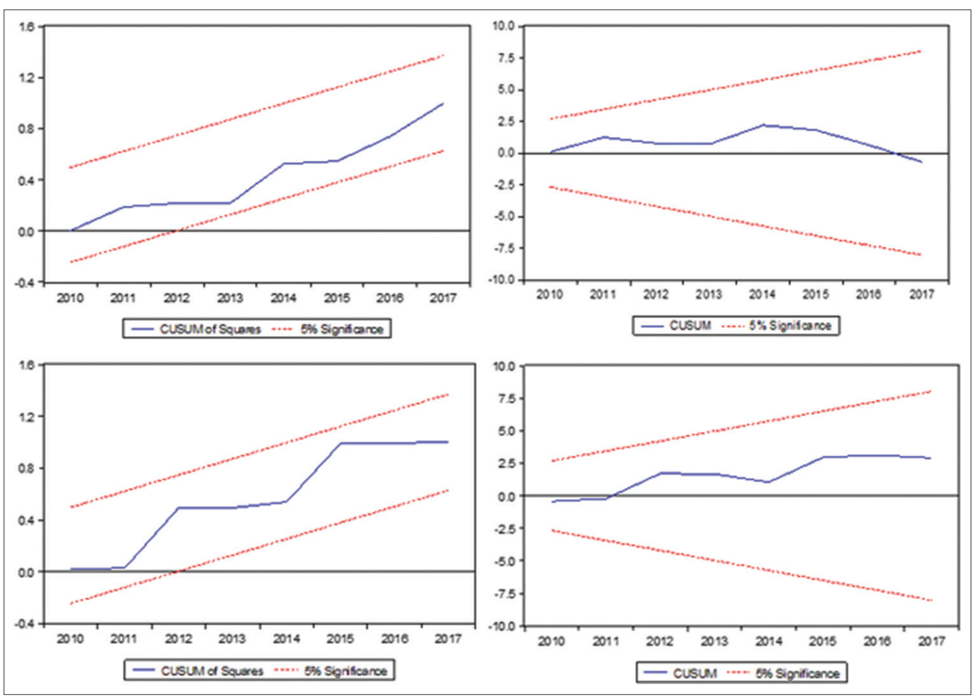
EX: Exchange rate or dollar price in domestic currency, P: Electricity price, PGA: Gasoline price, PNG: Natural gas price, IND: Industrialization, URB: Urbanization, GDP; Gross domestic production, RE: Electricity generation from renewable energies, NONRE: Electricity generation from non-renewable energies. The numbers in parenthesis show standard error research about total electricity generation or consumption. The study found that the dollar rate had a negative effect of 3.27 on electricity generation from renewable energy and a positive impact of 0.23 on electricity generation from non-renewable energy in the long run. An inverse relationship existed in the short run. However, the effect of the exchange rate on electricity generation has not been considered much; the finding can be compared with (Avdjiev et al., 2019), in which a stronger dollar is associated with lower real investment in emerging market economies. (Keeley and Matsumoto, 2018) also indicated that dollar fluctuations would negatively affect foreign direct investment in renewable energies from wind and solar in developing countries. The results of this study on electricity price indicated a negative relationship between electricity price and electricity generation from renewable energies with a coefficient of −7.49 in the short run and −0.16 in the long run and a positive relationship between electricity price and electricity generation from non-renewable energies with a coefficient of 0.3 in both the short and long run at the 10% level. However, the effect of electricity price on electricity generation from renewable energies is not significant in the long run. Kwon et al. (2016) found a negative relationship between electricity demand and electricity price, while Kok et al. (2018) discovered that different electricity prices had different results on investment in renewable energies from wind and solar. However, Al-Bajjali and Shamayleh (2018) discovered that electricity prices negatively affected electricity consumption. The present research results found that the prices of natural gas and gasoline, two primary fuel sources in Iran, had different effects on electricity generation from renewable energies and electricity generation from non-renewable energies. A unit increase in gasoline price and natural gas price changes electricity generation from renewable energies by 2.55 and 2.54 in the short run and 4.69 and −2.63 in the long run, respectively. Bernal et al. (2019) found fuel prices increased electricity generation, but Nakajima and Hamori (2012) discovered no significant effect of fuel price on electricity generation. The signs of coefficients, whether the dependent variable was electricity generation from renewable or non-renewable energies, were in line with expectations in this research except for the negative effect of natural gas on electricity generation from renewable energies in the long run. This result may be due to the strong effect of natural gas on the Iranian economy, where increased natural gas prices lead to decreased investment in renewable energies. Natural gas is an accessible fuel with a low cost in Iran, and the lives of Iranians are extremely dependent on this fuel, so any change may affect the economy (Bekhrad et al., 2020; Galadima and Aminu, 2020). The coefficient of industrialization significantly affects electricity generation from renewable energies by 1.18. Its effect is not significant for electricity generation from nonrenewable energies. The signs of urbanization and GDP were positive for both electricity generation from renewable energies and electricity generation from nonrenewable energies by 0.43, 1.49, and 0.17, 0.73, respectively. A similar result was found by Al-Bajjali and Shamayleh (2018) in a positive relationship between electricity consumption, GDP, and urbanization. (Shayanmehr et al., 2023) found Non-renewable energies increase the ecological footprint and destroy the environment. As was expected, the dummy variable of sanction had a negative effect on electricity generation from renewable energies but a positive effect on electricity

Table 4: ARDL diagnostic tests

Dependent variable test	RE	NONRE
Breusch-Godfrey serial correlation LM test	5.36 (0.06)	4.33 (0.11)
Jarque-Bera	0.07 (0.97)	1.45 (0.48)
Heteroskedasticity test: ARCH	24.08 (0.11)	20.95 (0.13)

The numbers in parenthesis indicate probabilities

Figure 1: Stability tests of ARDL model



generation from non-renewable energies. This may be due to the negative impact of sanctions on investment in renewable energies that cause a decrease in electricity generation from renewable energies to be compensated by electricity generation from non-renewable energies (Sadeghi and Larimian, 2018). (Adebayo and Ullah, 2023) found that the stability of the government can develop renewable energy consumption and environmental quality. (Adebayo and Ullah, 2023) found stability of the government can develop renewable energy consumption and environmental quality. The dummy variable for the Iran-Iraq war was insignificant because electricity generation from renewable energies continued its steady trend several years after the war. It is also noted that low fuel prices prevented the harmful effects on electricity generation from nonrenewable energies during wartime.

4. CONCLUSION AND POLICY IMPLICATIONS

Sustainable development, as one of every economy's ultimate goal, leads countries towards using clean energies. This paper considered effective factors for electricity generation from renewable energies and electricity generation from non-renewable energies in Iran. To reach this goal, the research employed the autoregressive distributed lag model and annual data from 1977 to 2018. The study tried to comprehensively investigate the factors that affect two kinds of electricity generation: gross domestic product, industrialization, urbanization, natural gas price, gasoline price, electricity price, and the dollar exchange rate. The results showed that in the short run, all factors affected electricity generation from renewable energies, while only natural gas price and industrialization affected electricity generation from non-renewable energies. In the long run, all coefficients of variables were significant except electricity price for renewable energies and gasoline price and industrialization for non-renewable energies.

The research has some policy implications for improving electricity generation from renewable energies. It is noticeable that industrialization, urbanization, and gross domestic product had positive effects on both types of models, while they were stronger for renewable energy electricity generation. The results also indicate that a gasoline price is a strong tool for leading electricity generation towards using renewable energies. So, any policy that leads to improvements in industrialization, urbanization, and gross domestic product along with an increase in gasoline price would develop electricity generation from renewable energies. Besides, the increase in the dollar rate in the long run negatively affected electricity generation from renewable energies. Policymakers must understand that dollar price variations would decrease electricity generation from renewable energies and must be controlled. Among dummy variables, nuclear sanctions negatively affected electricity generation from renewable energies, and the war was insignificant. The study has encountered some limitations, such as data frequency and available time series data. In Iran, data is not available in terms of long-term time periods or seasonal and monthly frequency. So, researchers have the limitation of a short sample size. Future studies can evaluate the effectiveness of economic factors on different types of electricity generation from renewable energies like wind, hydro, etc.

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