

# Renewable Energy and Economic Growth in Saudi Arabia: A Test of Interrelationship

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**Abstract:** In this paper, we examine the causal relationship between renewable energy and economic growth in Saudi Arabia from 1990 to 2021. Our hypothesis suggests a bidirectional causal link between economic growth and the adoption of renewable energy, emphasizing the significant impact of transitioning to renewables on Saudi Arabia's economic growth. The findings indicate a unidirectional causal relationship in the short and long term, with real GDP influencing actual investment spending and the labor force influencing real GDP. Moreover, there is a unidirectional causal relationship between real GDP to renewable energy, suggesting that real GDP drives the development of renewable energy in both the short and long term.

**Keywords:** Renewable Energy, Domestic Product, Labor Force, Investment Spending.

## 1 Introduction

Energy plays a vital role in economic, human, and social improvements, which are essential inputs for achieving sustainable development, especially in developing countries [1]. Energy consumption in developing countries is increasing rapidly in response to rapid economic growth, population growth, and industrialization. The demand for global primary energy is expected to increase, as the current policy scenario of the International Energy Agency predicts that the energy growth rate will be 1.4% annually until 2035 [2]. With non-OECD countries are facing a faster growth rate, especially China and India. but the main challenges that will meet the world regarding the continued growth of energy consumption are rising, unstable fossil fuel prices and the problem of climate change, i.e. global warming driven mainly by the burning of fossil fuels with its harmful impact on human beings and Organisms. All of this raises the world's concern about energy security, which will lead to the importance of transitioning to renewable energy resources, including renewable energy resources. [3]

Renewable energy is energy derived from wind energy [4], solar energy [5], biofuels, and hydroelectric energy (U.S. Department of the Interior Bureau of Reclamation Power Resources Office). And geothermal heat, which is known as clean energy, and switching to it will not only protect the environment but will also contribute to the growth of income and jobs, as most countries in the world are interested in diversifying sources of energy production. Especially energy production through natural sources called "renewable energy" which is Energy derived from inexhaustible natural resources and differs fundamentally from fossil fuels such as petroleum, coal, natural gas, or nuclear fuels that are used in nuclear reactors. Renewable energy is characterized by the fact that it does not produce environmental pollutants such as carbon dioxide or harmful gases that increase global warming, as happens when Fossil fuel combustion. [6,7,8]

The Gulf Cooperation Council countries have realized that there are better long-term solutions than energy based on fossil fuels [9]. The Gulf Cooperation Council countries must search for renewable energy sources for two reasons. The first reason is maintaining large oil reserves while spending energy from other sources. The second reason is to deal with potential environmental issues. As a possible alternative, the Gulf Cooperation Council countries are making great efforts to find a financially viable solution, considering the tremendous potential, as renewable energy, especially solar energy, is an excellent alternative to solar-based energy supplies. Fossil fuels are about renewable energy; essential steps have been made in recent decades. These schemes are generally related to solar energy; the second most common is wind energy, while the third most

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common is waste-to-energy. [10,11]

It should be noted that last year's importance statistics are still being determined. The share of renewable energy in final energy was found to be in most of the GCC countries Bahrain, Kuwait, Oman, and Qatar, according to World Bank data, and this percentage was located to be less than 1 in the UAE. The United Arab Emirates and the Kingdom of Saudi Arabia, although there are many ambitious projects in the region, are weak, and this is where policymakers in the Gulf Cooperation Council countries must make a great effort. It is easy to understand the low development of renewable energy in the countries concerned; there are two essential reasons: the lack of regulations promoting renewable energy and the heavily subsidized energy supply based on fossil fuels. Hence, these two issues must be addressed to develop renewable energy supplies. [12]

Many studies focus on the causal relationship between energy consumption or renewable energy consumption and economic growth because this is an essential indicator of correct policy decisions. If there is a bidirectional causal relationship between energy consumption and economic growth (feedback hypothesis), this indicates the interconnection between the two variables. If the causality is unidirectional but extends from economic growth to energy consumption (conservation hypothesis), this may reflect energy conservation policies' small or no effect on economic growth. On the contrary, the causality is unidirectional, extending from energy consumption. Economic growth (the growth hypothesis) indicates the importance of energy for economic growth. This means that energy conservation policies may negatively affect economic growth. Without a causal relationship between economic growth and energy consumption (the neutrality hypothesis), this reflects the small impact of energy policies. Conserve energy for economic growth. [2,13]

The study tests the relationship between renewable energy and economic growth in the Kingdom of Saudi Arabia (1990-2021). The study was based on the hypothesis that there is a two-way causal relationship between economic growth and renewable energy, meaning that using renewable energy causes the gross domestic product in the economy. Saudi Arabia as the GDP generates renewable energy, the renewable energy economy will have a large and significant impact on economic growth in the Kingdom of Saudi Arabia.

The study aims to test the validity of the hypothesis by relying on the inductive approach in collecting study data and conducting a test of the validity of the study hypothesis. To achieve the study's goal, it is proposed to divide the study into five main parts in addition to the introduction, which is Part 2, which explains previous studies, and Part 3, which illustrates a description of the study model. Part 4 described the unit root tests for stability of time series. Part 5 presented the results of the cointegration test. The last part included the conclusion.

## 2. Literature Review:

Many previous studies have addressed the relationship between renewable energy and economic growth, including [2,14,15,16,17]

Where [2] examines the relationship between Egypt's renewable electricity consumption, foreign direct investment, and economic growth. The study used the automatic distributed lag (ARDL) testing approach across time series data for the period (1980-2011). The study is jointly integrated, which indicates a long-run relationship between them. Moreover, renewable electricity consumption and foreign direct investment have a positive long-run impact on economic growth. The Granger causality test results also demonstrate a unidirectional causality extending from foreign direct investment. Economic growth, in addition to a two-way causal relationship between economic growth and consumption of renewable electricity, supports the feedback hypothesis, i.e., the importance of renewable energy on economic growth in the Egyptian economy.

A study by [14] discussed how oil competes with renewable fuels and examined the potential impact of a low oil price environment on these fuels. The study concluded that oil prices could affect the development of alternative energy sources in several ways; in transportation, lower oil prices could reduce the competitiveness of biofuels, which have made inroads against traditional fuels like gasoline in recent years. Cheaper gasoline prices could also reduce consumers' incentives to buy electric vehicles, which are currently more expensive. To purchase but less expensive to operate than vehicles with internal combustion engines, it is also possible that lower oil prices will lead to increased use of oil to generate electricity, leading to the substitution of renewable alternatives and thus increasing emissions from fossil fuels.

The study also found that the primary way lower oil prices could lead to competition for renewable energy sources, such as

solar and wind energy would be by causing natural gas prices to decline if rigs were redeployed from oil to gas.

A study [15] attempted to analyze the impact of the decline in oil prices 2014 on the future of renewable energy. The study concluded that the recent decline in oil prices so far has yet to result in a significant impact on the renewable energy sector. It also found that renewable energies, such as Solar and wind energy, are increasingly cost-competitive with fossil fuels. However, the collapse of oil prices could hurt the short-term outlook for some specific clean energy technologies, such as biofuels and electric vehicles that compete with oil-based transportation. Although long-term low oil prices may threaten renewable energies, climate policies can counterweight, encouraging long-term low-carbon investment and the future of oil as a significant energy source.

A Study by [16] highlights the role of renewable energies in achieving sustainable economic development, given that renewable energies have become an alternative to fleeting resources and that many countries rely on them to develop their economies at all levels. This study addressed all the concepts related to sustainable economic development and its dimensions, as well as the concept of renewable energies; it was concluded from the results that there is a positive impact relationship of renewable energies in achieving sustainable economic development for countries.

A Study by [17] aims to study the relationship between energy consumption, economic growth, and the impact of carbon dioxide emissions in the case of the Gulf Cooperation Council countries. The study relied on the VAR panel methodology in the period (1980-2014), and the results show that economic growth leads to higher energy consumption. However, it was found that there is a negative relationship between carbon dioxide emissions and economic growth, which indicates the great awareness of the Gulf Cooperation Council countries about the environmental problems associated with energy based on fossil fuels. Therefore, there is an incentive in these countries to deal with potential environmental issues, one of which is a good alternative is renewable energy; also, increasing energy efficiency is essential in the future.

Moreover, [18] attempted to analyze the strategies and investments of major oil companies in the field of renewable energy in response to this expectation of renewable energy sources assuming a more significant share of the global energy mix at the expense of hydrocarbons. Specifically, whether essential oil companies are turning into energy companies in the broader sense; the study found that five major oil companies out of eight have framed a renewable energy strategy and have begun significant investments in renewable energy.

The analysis also discovered a strong connection between the proven reserves of major oil companies and their renewable energy strategies. Big oil companies with fewer proven oil reserves to draw from appear to be moving faster into the renewable space to develop more diversified and less volatile portfolios sooner. However, the shift to renewable energy can be considered the most significant strategic direction for major oil companies in a generation that opens up prospects for further research.

A study by [19] aims to measure the impact of the consumption of renewable energies on economic growth in the countries of the Maghreb during the period 1995-2014. The panel data model methodology was adopted to achieve this goal, and the study results show that the impact of consumption is positive. Renewable energies have a positive impact on economic growth in the Maghreb countries. She also explained that investing in renewable energies is one of the essential conditions for economic growth and continuity, providing the needs of many remote areas for clean and sustainable energy and contributing to developing and encouraging these areas. To participate in the economic growth of the Arab Maghreb countries.

Then, [20] aimed to analyze the asymmetry or asymmetry in the impact of renewable energy consumption on economic growth in Morocco during the period (1971-2015). In addition, the research paper used a relatively modern standard methodology where the autoregressive model was applied for nonlinear distributed deceleration (NARDL). which was developed by Shin et al. in 2014, in addition to the Pairwise Granger Causality Test. The results indicated a long-term equilibrium relationship, a co-integration relationship, between renewable energy consumption and economic growth in Morocco. The results also showed an asymmetry in the effect of renewable energy consumption on economic growth in Morocco. The causality test also concluded that there is a one-way causal relationship between renewable energy consumption and economic growth, going from renewable energy consumption to economic growth, which means that renewable energy consumption significantly affects economic growth in Morocco.

The study of [21] entitled “The relationship between green energy, economic growth, and environmental quality in the Kingdom of Saudi Arabia” investigated the tripartite link between economic growth, renewable energy, and environmental

quality in the case of the Kingdom of Saudi Arabia using a simultaneous equation modeling approach during the period (1990-2016). In addition, the study results concluded that there is a unidirectional causal relationship between economic growth and renewable energy consumption in the Kingdom of Saudi Arabia, which confirms the conservation hypothesis. Bidirectional relationships were also found between economic growth and carbon dioxide emissions and between carbon dioxide emissions and renewable energy consumption. Among the study results was also the failure of renewable energy in the Kingdom of Saudi Arabia to bridge the gap between economic development and environmental protection in the Kingdom of Saudi Arabia. The hypothesis of the environmental Kuznets curve was also supported.

It should be noted that the current study differs from previous studies in that it is applied to the Saudi economy using time series data for the period (1990-2021) and relies on the VECM error correction model method to test the reciprocal relationship between renewable energy and economic growth.

### 3. Model Description:

Economic growth models and previous studies have relied on the Cobb-Douglas model in formulating the relationship between renewable energy and real GDP, including the study (2021) by Jarraya, B. et al. The Cobb-Douglas function can be expressed in the following mathematical form:

$$(1) \quad y_t = A K_t^\alpha L_t^\beta$$

$y_t$  Denotes the economic growth rate (measured by real GDP),  $A$  denotes the technological level (which is constant),  $K$  denotes capital,  $L$  denotes labor force,  $\alpha$  denotes the coefficient of elasticity of output concerning capital, and  $\beta$  denotes the coefficient of elasticity of output concerning labor force.

Given that, the primary objective of the study is to measure the causal relationship between renewable energy and real GDP in the Saudi economy. The percentage of renewable energy use out of energy use ( $E$ ) will be added as an explanatory variable that expresses renewable energy due to the availability of data on the Saudi economy during the study period to the equation. Number (1) to become as follows:

$$(2) \quad y_t = A K_t^\alpha L_t^\beta E_t^\gamma$$

The logarithm of both sides of equation (2) is taken to obtain the following linear equation.

$$(3) \quad \log y_t = b_0 + b_1 \log K_t + b_2 \log L_t + b_3 \log E_t + \epsilon_t$$

Equation (3) measures the relationship between renewable energy and gross domestic product in the Saudi economy in the short and long term. Since the variables are in their logarithmic value, the partial derivatives express the elasticity of the economic growth rate concerning the explanatory variables.  $b_1$  expresses the elasticity of the economic growth rate about the explanatory variables. Real GDP concerning spending for natural capital accumulation,  $b_1$  expresses the elasticity of real GDP growth concerning the labor force,  $b_2$  expresses the elasticity of real GDP about renewable energy,  $\epsilon_t$  is the random error term assuming that it achieves traditional statistical properties with an arithmetic mean equal to zero. And constant variance.

Regarding the data on the variables used in tests on the state of the Saudi economy during the period (1990-2021), it was collected from international sources, the "World Bank and INCAD database," and the Consumer Price Index (CPI) (2010=100) was used to obtain The actual values of these variables (GDP, capital accumulation).

According to the methodology used in the study, the methods used consist of three tests: unit root tests, Johansen cointegration test, and VECM error correction model.

### 4. Statistics Analysis:

#### 4.1. Unit Root Tests for Stability of Time Series:

The Unit Root Test aims to examine the properties of time series for real GDP, natural capital accumulation, labor force, which is a real variable, and a series of the percentage of renewable energy from energy use, using data on the Saudi economy during the period (1990). (2021) According to the latest available data, to identify the extent of its stationarity and to

determine the degree of integration of each variable separately, and despite the multiple unit root tests, the current study will use two tests: the Dickey and Fuller test, And the Philip-Perron test. Table (1) shows the study variables' ADF unit root test results.

Table (1)

Dickey and Fuller Test Results

The Unit Root of the levels and first differences of the study model variables

ADF-test									
Degree of co-integration	The first difference				Level				Time series
	General trend		Cross-section		General trend		Cross-section		
	Prob.*	t-Statistic	Prob.*	t-Statistic	Prob.*	t-Statistic	Prob.*	t-Statistic	
1	0.00	-4.88	0.00	-4.96	0.80	-1.51	0.77	-0.91	log y
1	0.34	-2.47	0.10	-2.61	0.37	-2.40	0.97	0.27	log L
1	0.02	-3.93	0.00	-3.99	0.84	-1.41	0.77	-0.90	log k
1	0.00	-8.41	0.00	-7.72	0.09	-3.26	0.05	-2.96	log E

Source: EViews 10

It is clear from the results of Table (1) that the series of real GDP and labor supply. in addition to the series of real capital accumulation, are unstable at the level. whether in a cross-section or a general trend, while the stability of the series of the percentage of renewable energy out of total energy at the level is apparent by imposing a cross-section at A significance level of 5% or assuming a cross-section and a general trend with a significance level of 9%. It is also evident that all-time series are stable when their first differences are taken, as the series of real GDP, the percentage of renewable energy, and actual total capital accumulation are stable when their first differences are taken apart. Assuming a cross-section or cross-section and a general trend with a significance level of less than 2%, the stability of the work series becomes apparent when taking its differences assuming there is only a cross-section with a significance level of 10%, Table (2) presents the results of the pp test for the unit root on the variables of the study.

Table (2)

Results of the Philippe-Perron Test (PP Test)

The Unit Root of the levels and first differences of the study model variables

PP Test									
Degree of co-integration	The first difference				Level				Time series
	General trend		Cross-section		General trend		Cross-section		
	Prob.*	t-Statistic	Prob.*	t-Statistic	Prob.*	t-Statistic	Prob.*	t-Statistic	
1	0.00	-4.83	0.00	-4.92	0.80	-1.51	0.78	-0.90	log y
1	0.50	-2.14	0.15	-2.40	0.37	-2.41	1.00	1.85	log L
1	0.02	-3.92	0.00	-3.98	0.92	-1.08	0.50	-1.54	log k
1	0.00	-8.64	0.00	-5.90	0.10	-3.21	0.01	-3.82	log E

It is clear from Table (2) that the results of Philippe Perron agree with the results of the Dickey-Fuller test with different levels of significance, as it is clear that the series of real GDP and labor supply, in addition to the series of real capital accumulation are unstable at the level, whether in segments and a general trend. The stability of the series of the percentage of renewable energy out of total energy at the level becomes clear by assuming a cross-section at a significance level of 1% or by adopting a cross-section and a general trend at a level of significance of 10%. the stability of the all-time series is also apparent when taking their first difference. as the series of actual gross domestic product and The percentage of renewable energy and real total capital accumulation is stable when taking its initial differences together, assuming a cross-section or a cross-section and a general trend with a significance level of less than 2%. The stability of the labor series also becomes apparent when taking its differences, assuming there is only a cross-section at a significance level of 15%.

**4.2. Co-integration Test Results:**

The study relies on Johansen cointegration and the VECM error correction model method to estimate cointegration.

**4.2.1 Results of the Johansen-Gillis Cointegration Test**

The Engle-Granger test was used to determine whether there is cointegration between the variables under study. However, the Engel-Granger test does not aim to determine the number of cointegration vectors between the variables under study, distinguishing the Johansen test from other cointegration tests. Through its ability to test the number of cointegration vectors between the variables under study, the Johansen test is considered a support for the results obtained from the Engel-Granger test if the Johansen-Juselius Cointegration test proves the existence of a single integration vector between the variables. Place of study. When it is confirmed that there is a single integration vector between the variables under study using the Johansen-Gessels test, then the equations of the error correction models can be estimated (Paltasingh and Goyar, 2013). If the null hypothesis is rejected, it indicates the presence of cointegration and, thus, a long-term relationship between variables. This means that the model will likely converge in the long run if shocks occur to the system. However, if there is no cointegration, only the short-run model should be estimated, i.e., the results of the vector autoregressive model VAR and not the VECM should be evaluated.

Table 3 shows the results of the Johansen-Logsel's test.

Table (3)

Johannes Geslis Test Results

Trace Test										
Imposing the number of cointegrating vectors (r)	Intrinsic value		Statistical or calculated value		The critical values of the test are at a 5% .significance level		The critical values of the test are at a 1% significance .level		possibility	
	Eigen Value		Statistic		Critical Value 5%		Critical Value 1%		Pro.	
	Cross-section	General trend	Cross-section	General trend	Cross-section	General trend	Cross-section	General trend	Cross-section	General trend
nothing	0.55	0.67	48.92	74.91	47.86	63.88	54.68	71.48	0.04	0.00
One at most	0.44	0.54	24.66	41.89	29.80	42.92	35.46	49.36	0.17	0.06
Two at most	0.22	0.32	7.48	18.52	15.49	25.87	19.94	31.15	0.52	0.31
Three at most	0.00	0.21	0.07	7.00	3.84	12.52	6.63	16.55	0.80	0.34
Maximal Eigenvalue Test										
nothing	0.55	0.67	24.26	33.02	27.58	32.12	32.72	37.49	0.13	0.04

One at most	0.44	0.54	17.18	23.37	21.13	25.82	25.86	30.83	0.16	0.10
Two at most	0.22	0.32	7.41	11.52	14.26	19.39	18.52	23.98	0.44	0.46
Three at most	0.00	0.21	0.07	7.00	3.84	12.52	6.63	16.55	0.80	0.34

(r) Denotes the number of cointegration vectors.

Source: Eviews10 output

It is clear from the results of Table (3). that the first hypothesis is statistically significant at the level of 5% and that all the values calculated for the impact test are the most essential critical values for this test for the first hypothesis at a significant level (5%). assuming the existence of (section or section and general trend).

Which indicates the non-acceptance of the null hypothesis ( $r = 0$ ). That there is no standard integration. and the acceptance of the alternative hypothesis ( $r \neq 0$ ). Which means the existence of joint integration between real GDP and its determinants in the model under study it is the labor force. Which is a real variable, real capital accumulation, and renewable energy according to the impact test by assuming the presence of a section or section. A general trend and a significant level of 5%.

In addition, it is noted that the results of the impact do not agree with the results of the maximum value test at the first hypothesis by assuming the existence of a section and a general trend together. But in the event that there is a difference between the critical values of the results of the Trace Test. with the results of the Maximal Eigenvalue test, as in the case of assuming a section Only the results of the impact test are preferred according to previous studies, including (Luutekpohl, et al., 2001).

It is also noted that the calculated values Statistic for the impact test exceed the critical values of this test for the first hypothesis at a significant level (1%) assuming the existence of (section or section and general trend), which indicates the possibility of rejecting the null hypothesis ( $r = 0$ ) that there is no standard integration and accepting the alternative hypothesis ( $r \neq 0$ ), which means the existence of a joint integration between the real GDP and its determinants in the model under study according to the impact test by assuming the existence of a section or section and a general trend at a significant level 1%.

It also appears from the results of Table (3) that the second hypothesis is statistically significant at a significant level of 5% or less in the case of the impact test. All the values calculated for the impact test are less than the critical values of this test for the second hypothesis at a significant level (1% and 5%). assuming the existence of (section or section and general trend), which indicates the absence of a vector for joint integration between the variables of the study, as evidenced by the agreement of the results of the impact test with the results of the maximum value test, when The second hypothesis.

#### 4.2.2 Error Correction Model (VECM) estimation results

The error correction model assumes the existence of two types of relationships between the real economic growth rate and its determinants: a long-term relationship and a short-term relationship, which is the immediate or direct relationship that appears between the rate of economic growth and its determinants in each period and is measured by the changes between them in each period. (Paltasingh, and Goyari, 2013: 94-95).

Through the error correction model test, the null hypothesis is tested for no causal relationship between the model variables versus the alternative hypothesis of a causal relationship between the model variables, where the t-statistic value of the slow error correction limit coefficient is used to infer the existence of a long-term causal relationship between the variables. The F-statistic value of the explanatory variables in error correction equations is used to identify a short-term causal relationship between the variables. (Tahira Al-Sayed, 2014: 45) The error correction equations were estimated for the variables between which a standard integration relationship was found, namely the economic growth rate, the growth rate of renewable energy consumption, the growth rate of private investment spending, and the growth rate of the labor force, and the results were prepared in Table (4).

Table (4)

Results of Causality Testing Using Error Correction Models

Direction of causality	slowdowns	Pro.	t-statistic value	Pro.	F-statistic value	Estimated regression equation
			Long Run		Short Run	
The equations of change in the logarithm of real GDP and the change in real investment expenditure						
$D(\log Y) \rightarrow D(\log K)$	(1)(1)	0.98	-0.02	0.95	0.11	$D(\log Y)=D(\log K)$
$D(\log K) \leftarrow D(\log Y)$	(1)(1)	0.01	2.68	0.01	4.91	$D(\log K)=D(\log Y)$
The equations of change in the logarithm of real GDP and supply of labor						
$D(\log Y) \rightarrow D(\log L)$	(1)(1)	0.08	-1.83	0.33	1.21	$D(\log Y)=D(\log L)$
$D(\log L) \leftarrow D(\log Y)$	(1)(1)	0.16	1.45	0.00	5.85	$D(\log L)=D(\log Y)$
Equations of change in real GDP logarithm and resident patent applications						
$D(\log Y) \rightarrow D(\log R)$	(1)(1)	0.83	0.29	0.41	-0.83	$D(\log Y)=D(\log R)$
$D(\log R) \leftarrow D(\log Y)$	(1)(1)	0.00	-3.86	0.01	4.98	$D(\log R)=D(\log Y)$

The results of Table (4) indicate the immateriality of the calculated F,t test value in the equation of change in the real GDP logarithm. while the significance of F,t calculated in the equation of change in real investment spending, and then it can be said that there is a one-way causal relationship in the short and long term from real GDP to real investment spending. i.e. real GDP causes capital accumulation in the short and long term.

As noted from Table (4) the significance of the value of the F test from real GDP to supply from labor, which means that a one-way causal relationship from real GDP to supply from labor, i.e. real GDP causes supply from labor in the short term.

It is also noted that the significance of the tests t and F calculated in the equation of change in the logarithm of renewable energy. which means, and this means that there is a one-way causal relationship from real GDP to renewable energy, meaning that real GDP causes renewable energy in the short and long term, and the results of the causality test can be summarized in Table (5)

Table (5)

Summary of Causality Test Results Using Error Correction Models

Real GDP and real investment spending	Causal direction	Short term	Unidirectional	From real GDP to real investment spending
		Long term	Unidirectional	From real GDP to real investment spending
Real GDP and strong labor	Causal direction	Short term	Unidirectional	From real GDP to labor force
		Long term	No causal relationship	Alternative energy does not cause the labor force, and real GDP does not cause the labor force in the long run, according to the results of the study.



Real GDP and Alternative Energy	Causal direction	Short term	Unidirectional	From output to alternative energy, real GDP causes alternative energy.
		Long term	Unidirectional	From output to alternative energy, real GDP causes alternative energy.

It is clear from Table (5) that the causal relationship between real GDP and real investment expenditure is unidirectional in the short and long term, from real GDP to real investment spending, as the output causes real investment spending in the short and long term. The causal relationship between real GDP and the labor force is one-way in the short term from the labor force to real GDP, while in the long run there is no causal relationship between output and labor force.

### 5. Conclusion:

The current study aimed to test the reciprocal relationship between renewable energy and economic growth in Egypt and in order to achieve the objective of the study was divided into five main parts in addition to the introduction. Which is the second part explaining previous studies, the third part explained a description of the study model, and the fourth part explained the unit root tests for the stability of time series. the fifth part explained the results of the joint integration test, the last part included the conclusion.

Part II, explanation of previous studies. It has been shown that there are many previous studies that tried to test the causal relationship between renewable energy and economic growth. which was not resolved by previous studies, i.e. previous studies did not resolve the direction of causality between renewable energy and economic growth. Part III, explain the description of the model. Part IV, explain the unit root tests for the stability of time series, and despite the multiplicity of unit root tests, but the current study used two tests: Dickey and Fuller test and Philip-perron test to confirm the stability of time series.

Part V, clarify the results of the joint integration test. As the study depends in estimating joint integration on the two methods: Johansen for co-integration and the method of error correction model VECM. And it has become clear from the Johansen method of joint integration that there is joint integration between real GDP and its determinants in the model under study. Which is labor force, which is a real variable, and real capital accumulation, and the percentage of renewable energy consumption of total energy according to the impact test and at a significant level of 5%. Assuming there is a section or section and a general direction.

It has also been shown that the causal relationship between real GDP and real investment spending is unidirectional in the short and long term, from real GDP to real investment spending, as the output causes real investment spending in the short and long term. The causal relationship between real GDP and labor force is one-way in the short term, from the labor force to real GDP, while in the long run there is no causal relationship between output and labor force.

The causal relationship between real GDP and renewable energy is one-way in the short and long term from real GDP to renewable energy, meaning that real GDP causes renewable energy in the long and short term, and the last part included the conclusion.

In addition, the causal relationship between real GDP and renewable energy is unidirectional in the short and long term from real GDP to renewable energy, i.e. real GDP causes renewable energy in the long and short term.

Overall, the relationship between "real GDP and renewable energy" is complex and multifaceted. Where there is a growing wave of academic research that assume that there is a positive relation between the two, but the strength and direction of the relation can vary based on a lot of factors, like the type of renewable energy technology, the economic development's level, and the specific country or region being studied. It is mean; one way in which renewable energy (RE) can contribute to economic growth (EG) is through the creation of new industries and jobs opportunities. The sector of renewable energy is a rapidly growing sector of the international economy, and it is expected to grow in the coming decades.

Renewable energy (RE) can also contribute to economic growth (EG) by increasing energy security and reducing the cost of energy. Renewable energy sources, such as wind power and solar, are becoming increasingly cost-competitive with fossil fuels. As a result, businesses that switch to renewable energy can save funds on their bills and overall cost according to energy. Additionally, renewable energy sources can help to reduce a country's reliance on imported fossil fuels, which can boost economic resilience and security.

However, it is important to note that the relation between economic growth and renewable energy is not always straightforward. Where, some studies have found that (RE) can have a negative impact on (EG) in the short term, because of investments in infrastructure can be costly. Additionally, the impact of (RE) on (EG) can vary depending on the technology. Such as, wind power and solar are generally more cost-competitive than other (RE) technologies, such as geothermal and biomass energy.

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