Research Paper

 Publisher: University of Tehran

Cite this article as: Kohanhoosh Nejad, R. (2023). Renewable Energy Consumption and the Transition to a Green Economy in Egypt. *Journal of World Sociopolitical Studies*, *7*(1), pp. 147-179. https://doi.org/10.22059/wsps.2023.365940.1384

Renewable Energy Consumption and the Transition to a Green Economy in Egypt*

Roohollah Kohanhoosh Nejad[1]

1. Assistant Professor of West Asian & African Studies, University of Tehran, Tehran, Iran (kohanhoosh@ut.ac.ir) 0000-0003-4871-6588

(Received: Jul. 30, 2022 Revised: Aug. 27, 2022 Accepted: Nov. 21, 2022)

Abstract

This paper aims at defining the green economy index and using econometric models in order to investigate the relationship between the consumption of renewable energy in Egypt's transition to a green economy. Results indicate that first, consumption of renewable energy can effectively increase the level of development of green economy in the short and long term. Second, improving capital spending and increasing employment leads to an increase in the green economy index. Third, the effect of non-renewable energy on the green economy index is inverse, although there is a direct relationship between non-renewable energy consumption and total energy consumption. Therefore, it is necessary to consider the green credit policy of the government and financial institutions in order to maximize the enhanced effect of renewable energy investment on the green economy. The government must therefore develop a series of incentive measures to support and encourage investment in financing renewable energy, pay attention to the fundamental and guiding role of large enterprises in promoting renewable energy consumption and the development of the green economy, and fully mobilize the enthusiasm of all types of enterprises in promoting the development of the green economy.

Keywords: Egypt, Green Economy Index, Renewable Energy Consumption, Transition

JEL Classification: B22, C32, N54, Q43

* The author has no affiliation with any organization with a direct or indirect financial interest in the subject matter discussed in this manuscript.

Journal of **World Sociopolitical Studies**| Vol. 7| No. 1| Winter 2023| pp. 147-179
Web Page: https://wsps.ut.ac.ir//Email: wsps@ut.ac.ir
eISSN: 2588-3127 PrintISSN: 2588-3119

1. Introduction

The increase in the rate of population growth and the accompanying increase in the rates of demand for food, energy and water, in addition to climate changes resulting from environmental deterioration, prompted these organizations to search for new mechanisms to achieve development. The green economy seemed to be one of the most important of these mechanisms, as it works to improve the well-being of individuals, and eliminate class among them in the long run, while ensuring intergenerational justice about resources.

The process of transitioning towards a green economy depends on main sectors in the economy. Perhaps the leading sector in this regard is the energy sector, with the development of renewable energy sources such as solar energy, wind energy, and biomass energy, the use of which does not result in any emissions that would harm the environment. In addition, it contributes to achieving development, and therefore advances production, achieving stability and growth. This creates new job opportunities, improves living standards, and reduces poverty.

Solar energy is the origin of all energies; man has benefited from this form of energy since ancient times in many applications such as drying agricultural crops, heating homes, and cooking food. The first global irrigation station powered by solar energy was established in Egypt in 1913. Egypt needs to bring in renewable energy sources and activate their efficiency as a basis to move forward towards rapid progress. This is because renewable energy sources play the role of an engine that stimulates the production process in the economy of all countries. The motivation to study Egypt is that the Arab Republic of Egypt is the most populous country in North Africa and the Arab region and home to one of the fastest-growing populations globally. The rapidly swelling number of inhabitants has led to a rapid increase in energy demand, putting a strain on the country's domestic energy resources, even amid substantial recent offshore natural gas finds. As fuel shortages heightened in 2014, the country's electricity generating capacity struggled to keep pace with rising energy demand. Egypt's economic development hinges on the energy sector, which represents 13.1% of overall gross domestic product (GDP). To meet burgeoning energy demand, the Egyptian government has pursued an energy diversification strategy, known as the Integrated Sustainable Energy Strategy (ISES) to 2035, to ensure the continuous security and stability of the country's energy supply (IRENA, 2018). Egypt is working on increasing the supply of electricity generated from renewable sources to 20% by 2022 and 42% by 2035. As part of the country's plan to become an energy hub, Egypt has constructed several energy interconnectors (International Trade Administration, 2022).

The main objective of this research is to shed light on the theoretical framework of the green economy and renewable energy, as a pioneering sector in the transition towards a green economy, as well as to find strong ways and strategies to implement the green economy in Egypt in order to achieve sustainable development. So the main question is: 'How has the use of renewable energy affected the development of the green economy in Egypt?'. The study assumes that the use of clean renewable energies will contribute to the transformation of the Egyptian economy towards a green economy by reducing the risks of non-renewable energy on the environment and contributing to energy savings in the long term. The Methodology of this study is based on examining the links between the consumption of renewable energy and the transition to a green economy. Many studies have used the neoclassical production function (Shahbaz et al., 2020) as follows:

$$(1) \qquad Y = f(K, L)$$

where:

Y: Gross Domestic Product, K: Capital, L: Labor

By juxtaposing the use of renewable and non-renewable energy with capital and labor, the general model of the production function is made, in which renewable and non-renewable energy consumption, capital and labor are individual inputs as follows:

$$(2) \qquad GEI = f(K, L, RE, NRE)$$

where the variable of renewable and non-renewable energy consumption was added, and the green economy development indicator was added instead of production.

where:

GEI: The green economy index, which includes the gross domestic product, represented by the per capita share of the gross domestic product, the energy consumption index, represented by the per capita consumption of each unit of energy and the composite index is calculated using the aggregative method, or the arithmetic or geometric mean.

The aggregation method was chosen between the three variables to develop the Green Economy Index has two main pillars which is energy consumption (reflected in per capita consumption of each unit of energy) and economic growth (reflected in GDP per capita).

This paper defines the green economy index system, as shown in the previous figure, where the first level indicators for measuring green economy development are energy consumption and economic growth. The corresponding second level indicators are energy consumption per unit of GDP and per capita GDP (Zhang, 2019).

By using factor analysis, this study finds that energy consumption and economic growth have a positive impact within the index as follows:

Table 1. Coefficient Analysis of the Green Economy Index Variables

Component Matrix	
Component	
ENERGY_CON_Per_capita	655
GDP per capita	745

Source: Author Calculation by SPSS-20

It should be noted that the green economy index differs from green economic growth, which is obtained by deducting the value of natural resource depletion and environmental pollution losses from the gross domestic product. A green economy at its core is a net positive outcome of economic growth. However, the Green Economy Index in this study is the indicator that takes economic benefits and environmental impacts equally as important (Lin, 2016).

Exploring the interdisciplinary aspects of green energy and transition to green economy, economic, environmental, and social factors interact within this context. The notion of green economy is more than just a green GDP that accounts for negative environmental externality in the accounting of the national output. The green economy concept defined by Bappenas was adopted from UNEP's green economy definition of an economic development model to support sustainable development with a focus on investment, capital, infrastructure, employment and skills to achieve social welfare and environmental sustainability (UNEP, 2012).

Green Economy refers to a sustainable planetary-wide economy, which applies to both at the terrestrial and marine (blue economy). All activities, investments, and infrastructure that fall under the green economy's umbrella are contrary to the brown-based economy. For instance, a green economy would emphasize the utilization of renewable energy for industry and transportation systems instead of fossil fuel, shifting to low carbon industries and promoting a circular economy; it should be environment friendly and improve economic productivity on land and marine without exploiting and without creating damage to the ecosystem. These economic activities will provide significant opportunities for high and green economic growth, while fostering social cohesion and improving natural carrying capacity – thereby directly contributing to the achievement of Sustainable Development Goals (Lestari et al. 2022).

2. Literature Review

The development of the green economy will guide the traditional industrial society towards achieving an energy revolution in the fields of production and consumption. From the perspective of economics, green transition can effectively promote the development of the process of adjusting economic structure and stabilizing growth. In this regard, literature review is divided into studies dealing with the relationship of renewable energy to economic growth, and studies dealing with the relationship of renewable energy to green economy.

Through an exploration of various methodological approaches used in previous research, as this paper is focusing on econometrics models, we come upon different models or tools that have been employed in studying green economy, including dynamic simultaneous-equation panel data approach, ARDL (Autoregressive Distributed Lag Stationarity) model, self-regressive-augmented transversal lag model (CSARDL), non-linear autoregressive-distributed lagged model (NARDL) etc. (see: Bhuiyan et al., 2022).

In the energy literature, the relationship between renewable energy consumption and economic growth has greatly attracted economists and policy makers, and several studies have addressed this relationship through the use of three different types of datasets namely time series, panel, and cross-sectional data.

Some of the previous literature paid more attention to the role of renewable energy consumption in economic growth, energy saving, and emissions reduction from the perspective of renewable energy and economic growth. Bhuiyan et al. (2022) review research reveals that renewable energy does not hinder economic growth for both developing and developed countries, whereas, there is little significance of consuming renewable energy (threshold level) on economic growth for developed countries. Wang et al. (2022) explored the relationship between renewable energy consumption and economic growth from new risk-based perspectives, including political risks, financial risks, economic risks and composite risks. The results indicate that when composite risks and political risks are used as threshold variables, there is a single threshold between renewable energy consumption and economic growth. When that threshold is exceeded, the positive effect of renewable energy on economic development increases. When economic risks and financial risks are used as threshold variables, there is a double threshold between renewable energy consumption and economic growth. When the first threshold value is exceeded, but not the second, renewable energy positively impacts economic development. However, when economic risk and financial risk do not lie between the two threshold values, there is an insignificant negative correlation between renewable energy consumption and economic growth. Koçak and Arkgünes (2017) found that renewable energy consumption has a positive effect on economic growth. However, some scholars have concluded that renewable energy consumption does not have a significant impact on economic growth (Menegaki, 2011) and it even hinders economic growth (Ocal & Aslan, 2013). Apergis and Payne (2012) have developed a statistical model where GDP is the dependent variable, while the main explanatory variables are electricity consumption from renewables and from conventional sources. Results revealed a bidirectional relationship between the consumption of renewable energy, conventional energy, and GDP, in the short and long term. There is also a short-term, two-way relationship between renewable and non-renewable forms of energy, which means that it is possible to switch between forms of energy.

Some literature specializes in studying the relationship between renewable energy consumption and economic growth in specific countries. For example, Gyimah et al. (2022) argue that the increase in renewable energy consumption has a positive effect on economic growth. The empirical results of our study suggest that, the use of renewable energy should be encouraged to promote economic growth. A study by Ntanos et al. (2018), which aimed to study the relationship between energy consumption derived from renewable energy sources, and the economic growth of countries, expressed in the GDP per capita for twenty-five European countries for the period from 2007 to 2016. Statistical analysis is based on descriptive statistics. The ARDL model was used, which revealed that all variables are related. It also indicated that there is a relationship between the dependent variable of GDP and independent renewable energy sources, and indicated the formation of total fixed capital and the labor force in the long term. Moreover, the results show that there is a higher correlation between renewable energy consumption and economic growth for countries with higher GDPs, than for those with lower GDPs.

The study of Salim et al. (2014) also specialized in analyzing data for OECD countries for the period 1980-2011. The study concluded that there is a long-term relationship linking energy consumption (green and traditional) with industrial production and economic growth. In addition, evidence was found for a bidirectional relationship between traditional energy consumption and short-run GDP growth.

Regarding Egypt, the study of Ma & Qamruzzaman (2022) revealed that the feedback hypothesis explains the relationship between technological innovation and environmental sustainability [TI←→EF] in Egypt and ecological footprint and urbanization in Egypt and Ethiopia. Moreover, unidirectional causality runs from ecological footprint to renewable energy consumption in Egypt and Ethiopia. Raihan et al. (2023) put forward policy recommendations in the areas of low-carbon economy, promoting renewable energy use, sustainable tourism, and climate-smart agriculture, which would ensure environmental sustainability by reducing emissions in Egypt. Hassanein Muhammad (2022) explores the impact, challenges, and opportunities associated with the green economy in Egypt. The environmental impact of the green economy in Egypt encompasses reduced carbon emissions through the adoption of renewable energy sources and the conservation of natural resources. By promoting sustainable practices, such as efficient water management and waste management, Egypt can mitigate climate change effects and safeguard its biodiversity. From an economic standpoint, green economy offers opportunities for job creation in sectors such as renewable energy, energy efficiency, waste management, and sustainable agriculture. This transition can contribute to reducing unemployment and poverty rates, while fostering innovation and technological advancements in green technologies. Moreover, green economy can attract investment and stimulate economic growth, positioning Egypt as a leader in renewable energy production. Sarhan (2023) explores Egypt's efforts to transition towards a green economy essentially by decoupling GDP growth from carbon emissions, highlighting the progress made so far and the challenges ahead. The paper presents an overview of the various policy initiatives, investment strategies, and technological advancements that Egypt has employed to reduce its carbon footprint and promote sustainable development. His paper recommends that Egypt adopt a complementary strategy that integrates climate action into its broader development objectives, which would require concerted efforts from various stakeholders. Furthermore, Egypt needs to continue implementing sustainable policies and innovative solutions to reduce its carbon footprint, while promoting economic growth.

Ibrahiem (2015) examines the relationship between renewable electricity consumption, foreign direct investment and economic growth in Egypt. In this regard the study uses Auto Regressive Distributed Lag (ARDL) bound testing approach over time series data from 1980 to 2011. The empirical findings reveal that the variables in the study are cointegrated, indicating the existence of long-run relationship among them. Sharaf (2016) investigates the causal relationship between energy consumption and economic growth in Egypt during the period 1980-2012, within a multivariate framework by including measures for capital and labor in the aggregate production function. The findings of this study provide empirical evidence that energy conservation policy has no negative effect on the growth prospects of the Egyptian economy in the long-run. Fawaz (2014) studied the economics of solar energy as renewable energy and the economic implications of its investments in Egypt. He concluded that the current global energy system based on fossil fuels will not meet the growing demand for energy in Egypt in the future, and that there are no sufficient policies and legislation to encourage investment in solar energy in Egypt. Meanwhile, the purpose of this study is to construct a green economy index to measure the level of transition to a green economy using econometrics models.

3. Renewable Energy and Transition to a Green Economy in Egypt

The environment depends on the economy to provide the capabilities that work to protect the environment, as well as to improve its quality; as a result, any damage to the environment as a result of misuse of resources, negatively affects those resources, as well as the level of economic activity. Accordingly the existence of economic activity and its ability to grow and continue depends on the ability of the environmental system, which is based on providing resources and eliminating waste. Therefore, green economy is considered a basis for achieving development and social justice, through the peaceful management of natural resources and ecosystems, in light of the environmental conditions that society is going through (Khidr, 2017).

3.1. The Concept of Green Economy

The word green means everything that is in the environment, but on the condition that it is friendly to it and does not cause pollution to it, or at least does not add or increase more burdens on the environment that harm it or lead to its deterioration. The economic aspect of the environment takes many forms, including groundwater, minerals in quarries, soil, air, forests and trees, and all of this applies to the rule in order to achieve economic development. Therefore, green economy appeared to preserve the environment, and to protect the global environment from deterioration (United Nations Environment Program, 2011).

The Green Economy Initiative of the United Nations Environment Program defines green economy as an economy that leads to the improvement of human well-being and social equity, while working to reduce environmental risks and ecosystem degradation, therefore leading to reduce carbon dioxide emissions.

Green economy is a new model of fast-growing economic development, whose basis is lies on a complete knowledge of environmental economics, which aims to address the mutual relationship between human economies and the natural ecosystem, and to show the adverse impact of human activities on the ecosystem, such as climate change, global warming, which is the opposite of the model known as the black economy, whose basis is based on fossil fuels, such as coal, oil and natural gas (Khanfar, 2014). The concept of green economy includes three basic elements or indicators (UNEB, 2009), namely:

- Environmental elements: reducing carbon dioxide in the air, protecting biodiversity and ecosystems, and achieving optimal use of energy and natural resources.

- Social elements: represented in creating suitable job opportunities (that do not pollute the environment), achieving justice for countries and future generations, reducing poverty, increasing welfare, improving the standard of living, working to provide social protection, and access to appropriate basic services.
- Economic elements: represented in driving innovation, encouraging technology transfer, maintaining the continuity of economic growth, and working to achieve sustainable development.

It can be argued that a green economy consists of:

a. Creating new green opportunities, meaning providing new economic and social opportunities based on new green activities which guarantees:

- Improving trade flows, with a focus on goods and services that serve the environment.
- Production and distribution of renewable energy.
- Innovation, research and development, technology transfer, and business growth.

This achieves many benefits, including promoting low-carbon activities, opening new areas for economic growth, providing new job opportunities, and new sources of income.

b. Making existing economic activities more environmentally friendly, in the sense of greening economic activities. This achieves many benefits, including reducing carbon emissions, improving public transportation, reducing water waste, improving food security, and reducing agricultural land degradation and desertification (Nefadi, 2017).

3.2. The Most Important Characteristics of the Green Economy

Green economy aims to promote sustainable development through the adoption of sound economic policies that preserve the environment and limit its deterioration as a result of climate changes, in addition to striving to limit the worsening effects of poverty in many countries. Green economy is characterized by a series of characteristics, the most important of which are the following (United Nations Environment Programme, 2011):

- Green economy is a means to achieve sustainable development, and is not a substitute for it.
- Green economy works to achieve integration between the dimensions of sustainable development.
- The necessity of adapting green economy from the national priorities and conditions.
- The need to apply the principle of shared responsibilities between the concerned agencies of the state.
- Green economy focus on resource efficiency and sustainable consumption and production patterns.
- Green economy is central to reducing poverty.
- Green economy preserves the sustainability of natural resources.

3.3. Efforts to Move towards a Green Economy in Egypt

Egypt's Car Exchange and Recycling Program: The Ministry of Finance, in cooperation with the private sector, some commercial banks, and an insurance company, facilitated the process of exchanging and recycling cars. Commercial banks reduced the interest rate in order to increase the demand for loans; forty-one thousand cars were exchanged, which helped reduce carbon dioxide emissions by sixty-one thousand tons annually.

Egyptian Pollution Control Project: The Environmental Affairs Agency established this project with the aim of improving public information, and it also worked to spread environmental awareness, and shed light on environmental problems related to industry in Egypt.

Cleaner Production Center: The Ministry of Trade and Industry, in cooperation with the United Nations Industrial Development Organization, established the Cleaner Production Center to work on providing services to the industrial sector in Egypt, which are:

- Providing technical assistance to the Egyptian industry through clean production programs, and providing studies showing the impact of various industries on the environment.
- Providing assistive technology for the use of chemicals, for example managing industrial waste and recycling it.
- Providing financial advice and acting as an intermediary to provide access to loans from the World Bank and the German Technical Cooperation Agency (GTZ).
- Providing training programs and working on participating in international projects.

Onera Systems company: It was established by the Middle East Engineering and Communications Company (MEET), an Egyptian joint stock company specialized in renewable energy equipment, including solar system, wind system, and fuel cells (Khanfar, 2014).

4. Description of the Model

The standard study was applied to Egypt as a developing country during the period from 2000 to 2020, and the time period was chosen according to the availability of data from the World Bank. The study is based on the impact of using renewable energies for the transition to a green economy, which is done through the use of the neoclassical production function. The study also relies on local reports of the Public Authority for Renewable Energy, as well as reports of the Ministry of Electricity and Energy, and the Ministry of Environment. The study is also based on related research papers and periodicals in Arabic and English. Therefore, the main hypothesis is that there is a positive statistically significant relationship between the consumption of renewable energy and the green economy index in Egypt.[1] The general form of the model can be formulated as follows:

$$GEI_t = K^{\beta 1}_t \; L^{\beta 2}_t \; RE^{\beta 3}_t \, NRE^{\beta 4}_t \qquad (3)$$

5. The Results of Estimating the Standard Model

This part of the study presents the stages of the estimation process on time series data from 2000 to 2020. The first steps are to test the stability and stillness of the time series, because this stage is important in order to determine the quality of the model. The study then moves on to examine causality between the model variables, in addition to using the relationships that can be linked by studying the simultaneous integration relationships of the Johanson test for the model variables in the long run. Before this, important tests will be presented, which have priority to prove the correctness of the study model, represented in the descriptive statistical tests of the explanatory variables.

---

1. Data Bases: The World Bank, n.d.; WorldOmeter, n.d.; Courshero, n.d.; ychart, 2022

5.1. Descriptive Analysis of Variables

First, it is necessary to conduct a set of descriptive statistical analyzes on the variables represented in the study model, which is illustrated in the following table:

Table 2. Descriptive Statistics for Study Variables

Variables	Variable	Number of Years	Average	Standard Deviation	Min	Max
Variable	Green economy index	21	2145	469	1480	2986
Independent variables	Gross capital formation	21	26492	14715	8155	53530
	employment	21	23.35	5.16	15.50	29.97
	Non-renewable energy consumption rate	21	2.56	0.98	1.25	4.29
	Renewable energy consumption rate	21	0.17	0.03	0.12	0.22

Source: Prepared by Author based on the Results of E-views 10

Through the previous table, we have:

- As for the Green economy index, the average of the index during the years of study reached 2145, while the standard deviation reached 769, the minimum was 1480 and the maximum was 2986., which indicates that green economy index increased steadily during the period from 2000 to 2020, with the exception of 2012, representing the January 25 revolution, which affected the Egyptian economy.

- As for the total capital, the average total capital during the study period reached 7747 dollars, while the standard deviation amounted to 26492 million dollars, the minimum was 53530.75, and the maximum was 8155 million dollars. This indicates that the total capital formation during the study period fluctuated steadily during the period from 2000 to 2020.

- Employment during the study period reached 23.35 million workers, while the standard deviation was 5.16, the minimum was 15.50 and the maximum was 29.97.

- As for non-renewable energy consumption, the average non-renewable energy consumption reached 2.56, while the standard deviation reached 0.98, the minimum was 1.251, and the maximum was 4.29. As a result, non-renewable energy consumption was steadily increasing during the study period.

- For the consumption of renewable energy, the average consumption of renewable energy reached 0.17, while the standard deviation was 0.033, and the minimum and maximum were 0.22, which indicates that the consumption of renewable energy increased with fluctuation during the study period.

5. 2. Testing the Stability and Static Variables of the Standard Model

In order to estimate the models for the time series data, the methodology used requires us to start by first studying the stability of time and sectional series for the various variables of the model for this study, and then moving on to study the long-term relationships and simultaneous integration tests for the variables that have the same degree of differentiation, which could be done by using a number of developed tests to analyze and examine the unit root of time series data.

Econometrics assumes that the variables are stable in mean and variance, so the stability of the variables used in measurement must be studied. Where performing regression using the method of least squares "OLS" without ensuring the stability of the variables leads to what is known as Spurious Regression, and the stability of the variables or time series (Brockwell & Davis, 1996) can be confirmed by applying the Augmented Dickey-Fuller (ADF) test and Phillips Perron (PP) test, which are known as unit root tests using fixed limit and time. The two tests differ in that in the first one, the data is assumed to be homogeneous and parametric, while the second test assumes that the data is non-parametric (Jain & Chetty, 2020) and the PP test takes into account errors with heterogeneous variance; Where these tests were applied on each variable separately, we reached the results shown in the table 3 in appendix. From this test, it can be noticed that the time series are all unstable at the level, which means there is a unit root problem (Prop** > 0.05), and these variables became stable after making the first differences, and they became integrated of the first degree (Prop**< 0.05). This is due to the nature of these variables; These variables had many fluctuations during the study period due to the increase in the study period.

By applying the Philips-Perron (PP) test (table 4 in appendix), results became similar to the results of the Augmented Dickey-Fuller (ADF) test. This means that the time series of variables were unstable at the level, and became stationary at the first differences, which indicates the possibility of a long-term relationship. Therefore, the simultaneous integration test will be used between the variables (Co-integration test) to determine whether there is a long-term relationship (Das, 2019), since in the case of a long-term equilibrium relationship using the Vector Error Correction Model

(VECM), and in the absence of a relationship long-run equilibrium, vector autoregressive model is used.

5. 3. Study the Simultaneous Co-integration Relationship between Variables

After conducting stability tests, and with the presence of some unstable variables that are integrated of the same degree, the following step is to test the simultaneous integration relationships between these variables using the Johansson test, which is based on unit root tests for the estimated residuals, and the VAR autoregressive model is used to determine the best lag period (Mills, 2015).

To determine the maximum lag period, we can rely on the number of years in the sample (t = 31), and the number of model parameters (k-1 = 4), and based on the E-views 10 data, we find that the maximum lag period is (Lag = 3) (Dhuria & Chetty, 2018).

To choose the appropriate lag period, the period in which the majority of tests are significant is chosen. This means that if three or four out of four parameters show the same number of laggards, they are selected*.

5. 4. Estimation of the VECM Model

The VECM is an error correction model, used to study the long-term equilibrium relationship between variables. In this model, the presence of co-integration is required, and VECM is based on restricting the long-term relationships of the variables (Al-janabi, 2020). The co-integration term is known as the error correction term; the deviation from long-run equilibrium is gradually corrected through a series of partial short-run adjustments. From the above, the existence of a co-integration relationship between the variables would be proved, so we will apply the Vector Error Correction Model (VECM). Then the long-run co-integration equation can be written as follows:

LN_GEIt-1 = -6.17 +0.23 Ln Kt-1 + 1.4 Ln Lt-1 + 1.24 Ln REt-1 – 1.55 Ln NREt-1

Results (table 5 in appendix) indicate that both work and consumption of renewable and new energy positively affect the green economy index, while non-renewable energy consumption negatively affects the green economy index, and this result is consistent with what is stated in economic theory. The consumption of non-renewable energy leads to an increase in carbon dioxide emissions, which is a negative component of the green economy index.

VECM model estimates and results (table 6 in appendix) show:

- The Green economy index is positively affected by the previous value in the previous year, while it was negatively affected in the previous year.
- Capital positively affects the green economy index during the previous year and the year before that.
- As for the renewable energy variable, it negatively affects in the first time period and positively in the second time period.
- As for non-renewable energy, it has a positive effect during both periods.

5. 5. Studying the Causal Relationship between Variables

Granger Causality Test is done. Causality in economics refers to the ability of one variable to predict (cause) another variable. This test focuses on the direct relationship between variables and their direction (unidirectional or bidirectional) (Greene, 2017). Using the E-views 10 program reveals (table 7 in appendix) that there is a unidirectional causal relationship between the logarithm of the green economy index and the logarithm of capital at a significance level of 5%, while there is no causal relationship between the logarithm of the green economy index and the logarithm of work at a significance level of 10%. There is a two-way causal relationship between the logarithm of the green economy index and the logarithm of non-renewable energy use at a significance level of 10%. There is a unidirectional causal relationship between the logarithm of the green economy index and the logarithm of renewable energy at a significance level of 10%.

6. Conclusion and Recommendations

By constructing a green economy index to measure the level of transition to a green economy, this paper adopts a model to explore the short-term and long-term relationship between renewable energy consumption and the green economy index. This study defines the green economy index for Egypt as a dependent variable, while renewable energy consumption, non-renewable energy consumption, labor and capital were chosen as independent variables to establish the co-integration relationship between variables. The key findings of this research are summarized below:

First, the consumption of renewable energy can effectively increase the level of development of green economy in the short and long term. There is also a two-way causal relationship between the two variables, which means that they are important to each other. Second, improving capital spending and increasing employment led to an increase in the green economy index. Third, the effect of non-renewable energy on the green economy index is inverse, although there is a direct relationship between non-renewable energy consumption and total energy consumption.

Based on the above results, the following recommendations can be made:

The development of the green economy cannot depend on the behavior of renewable energy consumption; investment in the green economy should also be specifically considered, and it is necessary to consider the green credit policy of the government and financial institutions in order to maximize the enhanced effect of renewable energy investment on the green economy. Green credit means that the bank takes the information related to the project and its operating company as the inspection standard in the process of lending, and then makes a loan decision. Green credit expects to rationally allocate credit funds through differentiated credit services, which will eventually lead to coordinated progress between finance and environmental protection. Prior studies have found that green credit helps banks avoid environmental risks, firms' green transformation and sustainable economic development (Yao et al., 2021). The greater the investment in renewable energy and thus the consumption of renewable energy in the long term, the higher the level of development of green economy, which means the flow of green credit resources to the renewable energy industry helps to promote green economic development. Therefore, the government must develop a series of incentive measures to support and encourage investment in financing renewable energy.

The government should also pay attention to the fundamental and guiding role of large enterprises in promoting renewable energy consumption and the development of green economy, and fully mobilize the enthusiasm of all types of enterprises in promoting the development of green economy.

References

Al-janabi, N. (2020). Time Series Analysis Using E-views Program. https://www.researchgate.net/publication/342165890_Time_series_analysis_using_E-views_program

Apergis, N., & Payne, J. E. (2012). Renewable and Non-Renewable Energy Consumption-Growth Nexus: Evidence from a Panel Error Correction Model. *Energy Economics*, *34*(3), 733–738. https://doi.org/10.1016/j.eneco.2011.04.007

Bhuiyan, M. A., Zhang, Q., Khare, V., Mikhaylov, A., Pinter, G., & Huang, X. (2022). Renewable Energy Consumption and Economic Growth Nexus—A Systematic Literature Review. *Front. Environ. Sci*. *10*, 878394. https://doi.org/10.3389/fenvs.2022.878394

Brockwell, P. J., & Richard, A. D. (1996). *Introduction to Time Series and Forecasting*. Springer-Verlag New York.

Coursehero. (n.d.). Egypt. https://www.coursehero.com/file/56594670/Egypt-Total-Primary-Energy-Production-Consumption-Energy-Intensity-1980-2012xlsx/

Das, P. (2019). *Econometrics in Theory and Practice: Analysis of Cross Section, Time Series and Panel Data with Stata 15.1*. Springer. https://doi.org/10.1007/978-981-32-9019-8

Dhuria, D., & Chetty, P. (2018, Sep. 27). Lag Selection and Cointegration Test in VAR with Two Variables. *Project Guru*. https://www.projectguru.in/lag-selection-cointegration-test-var-two-variables/.

Fawaz, M. A. (2014). The Economics of Solar Energy as Renewable Energy and the Economic Impacts of Investing in Egypt. (Doctoral dissertation, Department of Economics, Cairo University). …

Greene, W. (2017). *Econometric Analysis*. Pearson

Gyimah, J., Yao, X., Tachega, M. A., Hayford, I. S., & Opoku-Mensah, E. (2022). Renewable Energy Consumption and Economic Growth: New Evidence from Ghana. *Energy*, 248, 123559. https://doi.org/10.1016/j.energy.2022.123559

Hassanein Muhammad, H. (2022). Impact of the Green Economy on Sustainable Development in Egypt Challenges and Opportunities. *International Journal of Humanities and Language Research*, *5*(1), 13-25. https://ijhlr.journals.ekb.eg/article_303612_ded48912d42333fc6aa577d6e0827d49.pdf

International Trade Administration. (2022), Egypt – Country Commercial Guide: Electricity and Renewable Energy https://www.trade.gov/country-commercial-guides/egypt-electricity-and-renewable-energy

Ibrahiem, D. M. (2015). Renewable Electricity Consumption, Foreign Direct Investment and Economic Growth in Egypt: An ARDL Approach. *Procedia Economics and Finance*, *30*, 313-323. https://doi.org/10.1016/S2212-5671(15)01299-X

IRENA. (2018). *Renewable Energy Outlook: Egypt*. International Renewable Energy Agency, Abu Dhabi. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Oct/IRENA_Outlook_Egypt_2018_En.pdf?rev=6c21d902a8d943798abe082a58ec2ce8

Jain, R., & Chetty, P. (2020, Feb. 12). What Is a Stationarity Test and How to Do It?. *Project Guru*. https://www.projectguru.in/what-is-a-stationarity-test-how-to-do-it/

Khanfar, A. R. (2014). Al-eqtesād (al)bey'i: Al-eqtesād (al)axzar [Environmental Economics: “Green Economy”]. *Assiut Journal of Environmental Studies*, 39, 53-56. https://search.emarefa.net/detail/BIM-525592

Khidr, A. (2017), Green Economy, Alternative Pathways to Sustainable Development - Science and Technology Magazine File, Kuwait Research Institute, https://www.kisr.edu.kw/ar/publications/science-technology-magazine/

Koçak, E., & Sarkgünesi¸ A. (2017). The Renewable Energy and Economic Growth Nexus in Black Sea and Balkan Countries. *Energy Policy*, *100*, 51-57. https://doi.org/10.1016/j.enpol.2016.10.007

Lestari, A., Putri, A., Napitupulu, A., Amalia, A., Putri, A. P., Armanto, A. N., Ramdani, D. A., Suarga, E., Damayanti, H., Medrilzam, I. D., Nasution, M. I., Gardian, P. I., Firmansyah, R., Ida, S., & Dwitiyasih, T. (2022). *Green Economy Index: A Step Forward to Measure the Progress of Low Carbon & Green Economy in Indonesia*. The Ministry of National Development Planning of the Republic of Indonesia (Bappenas). https://lcdi-indonesia.id/wp-content/uploads/2022/08/Green-Economy-Index-A-Step-Forward-to-Measure-the-Progress-of-Low-Carbon-and-Green-Economy-in-Indonesia.pdf

Lin, Y. S. (2016). Economic Reason and Comprehensive Management of Environmental Pollution in China. Beijing Normal University Publishing House.

Ma, C., & Qamruzzaman, M. (2022). An Asymmetric Nexus between Urbanization and Technological Innovation and Environmental Sustainability in Ethiopia and Egypt: What Is the Role of Renewable Energy? *Sustainability*, *14*(13), 7639. https://doi.org/10.3390/su 14137639

Menegaki, A. N. (2011). Growth and Renewable Energy in Europe: A Random Effect Model with Evidence for Neutrality Hypothesis. *Energy Economics*, *33*(2), 257-263. https://doi.org/10.1016/j.eneco. 2010.10.004

Mills, T. C. (2015). *Time Series Econometrics a Concise Introduction*. Palgrave Macmillan, UK.

Nefadi. M. S. (2017). Al-eqtwsād al-axzar ka-ahad- āliyāt a(l)ttamanniya(t) al-mostadāma(t) lejazb-el-estesmār al-ajnabi (derāsat-al-meydāniyya(t) be-(l)ttatbiq al-al bey'at-e a—mesriyya(t) [The Green Economy as a Mechanism for Sustainable Development: A Field Study Applied to the Egyptian Environment], *Scientific Journal of the Faculty of Commerce, Al-Azhar University, 17*(1), 1-32 10.21608/jsfc.2017.26710, https://jsfc.journals.ekb.eg/article_ 26710.html

Ntanos, S., Scordoulis, M., Kyriakopoulos, G., Katsarou, G., Chalikias, M., Galatsidas, S., Batzios, A., & Katsarou, A. (2018). Renewable Energy and Economic Growth: Evidence from European Countries. *Sustainability*, *10*, 2626. https://doi.org/10.3390/su10082626

Ocal, O., & Aslan, A. (2013). Renewable Energy Consumption Economic Growth Nexus in Turkey. *Renewable and Sustainable Energy Reviews*, *28*(8), 494-499. https://doi.org/10.1016/j.rser.2013.08.036

Raihan, A., Ibrahim, S., & Muhtasim, D. A. (2023). Dynamic Impacts of Economic Growth, Energy Use, Tourism, and Agricultural Productivity on Carbon Dioxide Emissions in Egypt. *World Development Sustainability*, *2*, 100059. https://doi.org/10.1016/ j.wds.2023.100059

Salim, R. A., Hassan, K., & Shafiei, S. (2014). Renewable and Non-Renewable Energy Consumption and Economic Activities: Further evidence from OECD Countries. *Energy Economics, 44*, 350–360. https://doi.org/10.1016/j.eneco.2014.05.001

Sarhan, A. A. (2023). Towards Green Economy in Egypt: Decoupling Economic Growth Andcarbon Emissions. *Journal of Environmental Science*, *52*(4), 23-68. https://jes.journals.ekb.eg/article_318195_eddabac31607da6e8d7426e454f4f8d3.pdf

Sharaf, M. F. (2016). Energy Consumption and Economic Growth in Egypt: A Disaggregated Causality Analysis with Structural Breaks. *Energy*, *46*, 59-76. https://regionetdeveloppement.univ-tln.fr/wp-content/uploads/5_Sharaf.pdf

Shahbaz, M., Raghutla, C., Chittedi, K. R., Jiao, Z. L., & Vo, X. V. (2020). The Effect of Renewable Energy Consumption on Economic Growth: Evidence from the Renewable Energy Country Attractive Index. *Energy*, *207*, 118162. https://doi.org/10.1016/j.energy.2020.118162.

The World Bank. (n.d.). Egypt, Arab Rep. https://data.worldbank.org/country/egypt-arab-rep?view=chart.

UNEB. (2009). *Global Green New Deal, Policy Brief*. The United Nations Environment Program as Part of Its Green Economy Initiative in Collaboration with a Wide Range of International Partners and Experts. https://wedocs.unep.org/20.500.11822/7903

UNEP. (2012). Measuring Progress towards an Inclusive Green Economy. United Nations Environment Program. https://wedocs.unep.org/20.500.11822/32438.

United Nations Environment Program. (2011). *Towards a Green Economy, Pathways to Sustainable Development and Poverty Eradication*.https://sustainabledevelopment.un.org/index.php?page=view&type=400&nr=126&menu=35

Wang, Q., Dong, Z., Li, R., & Wang, L. (2022), Renewable Energy and Economic Growth: New Insight from Country Risks, *Energy*, *238*(C), 122018. https://doi.org/10.1016/j.energy.2021.122018.

WorldOmeter. (n.d). Egypt Energy. https://www.worldometers.info/energy/egypt-energy/

Yao, S., Pan, Y., Sensoy, A., Uddin, G. S., & Cheng, F. (2021). Green Credit Policy and Firm Performance: What We Learn from China. *Energy Economics*, *101*, 105415. https://doi.org/10.1016/j.eneco.2021.105415.

Ychart. (2022). Egypt Primary Energy Consumption. https://ycharts.com/indicators/egypt_primary_energy_consumption

Zhang, L., Zhong, Z., Wang, D., & Wang, F. (2019). Green credit, renewable energy investment and green economy development: Empirical analysis based on 150 listed companies of China. *Journal of cleaner production*, *208*, 363-372. https://doi.org/10.1016/j.jclepro.2018.10.119

Appendix

Table 3. Augmented Dickey-Fuller (ADF) Test of the Study's Variables and Their Stability

Test type		None		Trend & Intercept	
variables		**.Prob	Statistic	**.Prob	Statistic
Ln (GEI)	Level (0)	3.20	0.99	-3.005	0.147
	First differences (1)	-1.08	0.24	-3.54	0.054
Ln(K)	Level (0)	1.88	0.98	-3.08	0.12
	First differences (1)	-3.48	0.001	-3.96	0.021
Ln(L)	Level (0)	2.06	0.98	1.46	1.0
	First differences (1)	-1.02	0.26	-4.06	0.017
Ln(NRE)	Level (0)	4.39	0.99	-2.60	0.28
	First differences (1)	-0.65	0.42	-4.71	0.0040
Ln(RE)	Level (0)	-1.86	0.06	-3.09	0.12
	First differences (1)	-6.22	0.00	-5.68	0.0004

Source: Prepared by Author Based on the Results of E-views 10

Table 4. Philips-Perron (PP) Test of the Study's Variables and Their Stability

Test type		None		Trend & Intercept	
Variables		**.Prob	Statistic	**.Prob	Statistic
Ln (GEI)	Level (0)	5.5	0.99	-2.2	0.46
	First differences (1)	0.014	-3.41	0.24	-1.07
Ln(K)	Level (0)	0.30	-2.53	0.96	1.58
	First differences (1)	-3.52	0.001	-3.93	0.022
Ln(L)	Level (0)	3.82	0.99	1.18	0.99
	First differences (1)	-1.94	0.05	-4.23	0.01
Ln(NRE)	Level (0)	3.99	0.99	-2.67	0.25
	First differences (1)	-3.31	0.001	-6.81	0.00
Ln(RE)	Level (0)	-5.99	0.00	-3.48	0.058
	First differences (1)	-6.28	0.00	-15.46	0.00

Source: Prepared by researcher based on the results of E-views 10

Table 5. Results of the Co-integration Equation

CointEq1	Co-integrating Eq
1.00	LN_GEI_(-1)
0.23	LN_K(-1)
(0.026)	
[8.80]	
1.23	LN_RE_(-1)
(0.10)	
[11.29]	
1.39	LN_L_(-1)
(0.27)	
[5.15]	
-1.54	LN_NRE_(-1)
(0.16)	
[-9.32]	
-6.175	C
(0.63)	
[-9.70]	

Standard errors in ( ) & t-statistics in [ ]

Source: Prepared by Author Based on the Results of E-views 10

Table 6. VECM Model Estimates and Results

D(LN_GEI_)	Error Correction
- 0.14	CointEq1
(0.05)	
[-2.56]	
0.63	D(LN_GEI_(-1))
(0.22)	
[2.87]	
-0.012	D(LN_GEI_(-2))
(0.24)	
[-0.05]	
0.02	D(LN_K(-1))
(0.02)	
[1.29]	
0.01	D(LN_K(-2))
(0.01)	
[0.54]	
-0.14	D(LN_RE_(-1))
(0.07)	
[-2.02]	
0.03	D(LN_RE_(-2))
(0.05)	
[0.63]	
0.14	D(LN_L_(-1))
(0.15)	
[0.93]	
-0.31	D(LN_L_(-2))
(0.16)	
[-1.91]	
0.11	D(LN_NRE_(-1))
(0.09)	
[1.26]	
0.063	D(LN_NRE_(-2))
(0.07)	
[0.80]	

Standard errors in ( ) & t-statistics in [ ]

Source: Prepared by Author Based on the Results of E-views 10

Table 7. Causality Test between the Dependent Variable and the Independent Variables

Prob.	F-Statistic	Null Hypothesis:
0.25	1.43	LN_K does not Granger Cause LN_GEI_
**0.02	4.29	LN_GEI_ does not Granger Cause LN_K
0.52	0.66	LN_L_ does not Granger Cause LN_GEI_
0.94	0.052	LN_GEI_ does not Granger Cause LN_L_
**0.003	7.04	LN_NRE_ does not Granger Cause LN_GEI_
*0.07	2.87	LN_GEI_ does not Granger Cause LN_NRE_
0.30	1.23	LN_RE_ does not Granger Cause LN_GEI_
*0.07	2.94	LN_GEI_ does not Granger Cause LN_RE_

** Significant at 0.05

*Significant at 0.1

Source: Prepared by researcher based on the results of E-views 10