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Investigating the N-Shaped Energy-Environmental Kuznets Curve Hypothesis in Saudi Arabia

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ABSTRACT

The Environmental Kuznets Curve (EKC) is extensively investigated in the literature, but testing of energy-EKC is scarce in the literature. The testing of energy-EKC is very important for extensive nonrenewable energy users. This research investigated the energy and growth cubic relationship in Saudi Arabia to verify the N-shaped energy EKC from 1970-2019. The estimated long-run parameters of linear, quadratic, and cubic terms of economic growth are found positive, negative, and positive, respectively. Hence, energy-EKC is corroborated in Saudi Arabia in the long run with the first turning point of N-curve at Gross Domestic Product (GDP) per capita of 19277 constant US dollar and the second point at 30880. Hence, the increasing GDP per capita before 19277 and after 30880 would increase energy use and have environmental consequences. The increasing GDP per capita between 19277 and 30880 would decrease energy consumption and is pleasant for the environment. The same behavior of energy usage is found in the short run. Hence, the energy-EKC is also validated in the short run.

Keywords: The Energy EKC, Energy Consumption, Economic Growth, Cointegration
JEL Classifications: Q42, O44, C22

1. INTRODUCTION

The environmental effects of energy use and growth are well explored in the energy and environmental literature through the Environmental Kuznets Curve (EKC). The EKC testing initiated by Grossman and Krueger (1991) and a gulf of literature has investigated this issue in the growth and pollution relationship. The investigation of the energy-EKC is very limited to verify the nonlinear relationship between growth and energy variables. Suri and Chapman (1998) had initiated the testing of the energy-EKC hypothesis. They worked on the idea that the manufacturing sector played a prominent role in shaping the energy and growth relationship in any economy. They claimed that exports' production would be accelerated the energy usage as a production process of any product needs energy. On the other hand, imported products would reduce the energy need. Because these products have to produce locally, if not imported and required energy consumption in the production process. On the other hand, energy demand might reduce if these products are not produced locally and are imported. On the whole, exports would increase, and imports would decrease energy usage. In addition, the contribution in manufacturing income also raised the energy use. The different stages of economic growth would also change the quantity or type of energy demand. Because a higher quantity of energy or dirty types of energy would be expected at a lower level of development. Later on, a better type of energy or lower energy quantity would be utilized on a higher stage of development. Hence, a nonlinear relationship of energy and growth is pertinent to test in the quadratic settings. In addition, the energy demand may also be expected to rise again on the third level of development, which would form an N-curve between growth and energy. Hence, testing the cubic relationship would display a better picture of the energy and growth relationship.

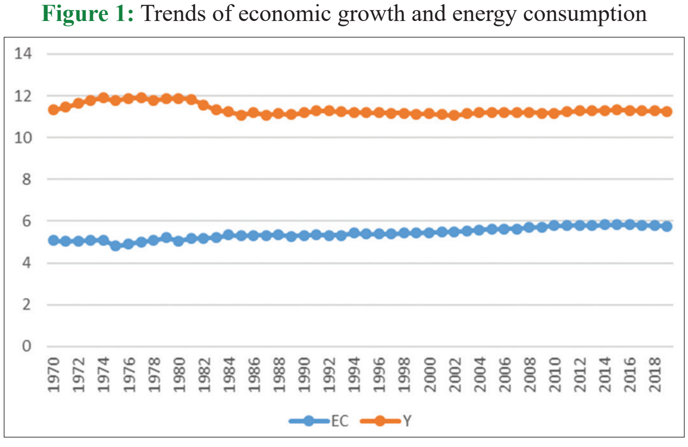
Saudi Arabia primarily depends on fossil fuel, and growth played a prominent role in determining the energy consumption behavior of this economy. For example, increasing economic growth may accelerate the energy usage in the economy to fuel economic activities because both production and consumption activities are required energy to run. On the other hand, energy consumption may switch from nonrenewable to cleaner sources due to increasing growth. Moreover, the type of production may switch from a dirty process to a cleaner one. The manufacturing income may also shift to non-manufacturing income like from the service sector. Figure 1 shows a nonlinear behavior of the logarithms of energy consumption (EC) and economic growth (Y) relationship, proxy by per head Gross Domestic Product (GDP). The movements of Y and EC can be seen in the same direction in most of the sample period. Nevertheless, the opposite behavior is also evident. For instance, Y and EC are moving in opposite directions during 1970-1971, 1977-1978, 1980-1984, 1987-1988, 1993-1994, 2001-2002, 2005-2007, 2008-2009 and 2012-2013. Hence, the relationship may not be assumed linear and the same in all the sample periods. Therefore, we assume the nonlinear relationship between EC and Y in the present study.

The interrelation between energy and income is yet not decided in the literature. The literature has found both evidence of existence and nonexistence of the energy-EKC. Moreover, the energy-EKC is missing in the case of the Saudi economy. Therefore, it is essential to thoroughly inquire about this connection before designing the strategy for optimum energy use and controlling pollution. The various forms of this interconnection may be assumed due to the variation in the functional form of each study for various data sets in different regions or country-specific cases in global literature. It has allowed us to inquire that which form of liaison is relevant in Saudi Arabia. Therefore, this study is designed to inquire about the consequences of nonlinear terms of income on energy use to conclude which strategy could control pollution into the economy. For this purpose, we utilize cointegration on the time series of 1970-2019.

2. LITERATURE REVIEW

The EKC investigated a lot in the literature between emissions and growth nexus. Many studies have focused on the different panels. For instance, Alam et al. (2016) investigated the EKC in four large polluter economies from 1970 to 2012. They found that energy use and income increased the emissions in all countries. Population in India and Brazil enhanced the emissions. The EKC was found in Indonesia, Brazil, and China. However, it was not found in India. Hence, three of four tested economies' growth did not have environmental consequences. In India, a monotonic positive effect of growth on emissions was observed. Al-Mulali et al. (2016) inspected the EKC in 7 regional analyses from 1980 to 2010. They established the negative impact of Renewable Energy Consumption (REC) in all investigated regions. The EKC was corroborated in the regions with a higher percentage of REC. Shahbaz et al. (2016) probed the EKC in nineteen African countries from 1971 to 2012. Globalization helped to decrease the emissions in the panel. Globalization helped to reduce emissions in nine and raised emissions in five investigated countries. The EKC was found in six investigated countries, and U-curve was found in two countries. Moreover, energy intensity was responsible for raising the emissions in 15 investigated countries.

Figure 1: Trends of economic growth and energy consumption



Le and Ozturk (2020) investigated the EKC in forty-seven developing countries from 1990 to 2014. They found the cross-dependence in the panel and hence applied cross-dependence estimators on the panel. They found that globalization and energy use accelerated emissions. Moreover, Financial Development (FD) also raised the CO_2 emissions. Moreover, they found feedback effects of all investigated variables with the emissions. Keho (2017) explored the EKC in different countries' groups of fifty-nine economies, using quantile regression. He validated the EKC in three of five investigated panel groups. Solarin et al. (2017) investigated the EKC in China and India during 1965-2013. They found that urbanization increased emissions. Moreover, real income growth also accelerated the emissions in India and China. However, hydroelectricity helped to reduce emissions. The EKC was also found in India and China, and feedback effects also corroborated among most of the variables in both countries. Saqib (2018) investigated the energy, growth, and emissions nexus in Gulf countries from 1996 to 2017. They found feedback in growth and energy relationship and growth and emission. Moreover, one-way causation from energy to emission was also found.

In the country-specific EKC studies, El-Aasar and Hanafy (2018) investigated the EKC between emissions and growth in Egypt from 1971 to 2012. They could not validate the EKC in Egypt. REC reduced emissions, and trade could not affect the emissions. Saudi et al. (2019) investigated the EKC in Malaysia from 1980 to 2017 and corroborated the EKC. Moreover, they found that innovation and REC helped to reduce emissions, and non-REC accelerated the emissions. Sarkodie and Ozturk (2020) investigated the EKC in Kenya from 1971 to 2013. They proved the EKC in emissions and income relationships. Moreover, energy usage raised the emissions in Kenya. Moreover, household consumption raised the energy demand. Urbanization increased the energy demand. However, energy imports did not show any effect on the availability of sustainable sources in Kenya.

Al-Mulali et al. (2015a) inspected the EKC from 1980 to 2012. They found that fossil fuels raised emissions in Kenya. Further, urbanization and trade put fuel on the fire and accelerated the emissions. Nevertheless, REC and FD decreased the emissions in Kenya. They found a monotonic positive effect of GDP on emission, and hence the EKC was not found. Al-Mulali et al. (2015b) investigated the EKC from 1981 to 2011. The authors found that capital raised the pollution emissions hence corroborated pollution haven theory in Vietnam. Imports increased the emission. Nevertheless, exports could not affect the emissions. Fossil fuel accelerated the emissions, and REC did not have any effect. Moreover, the labor also helped to reduce pollution as most of the labor was employed in the agriculture and service sector. Rabbi et al. (2015) investigated the EKC in Bangladesh from 1972 to 2012. They found the U-curve between emissions and growth. Balibey (2015) explored the EKC in Turkey from 1974 to 2011, controlling Foreign Direct Investment (FDI) in analyses. They confirmed the EKC in Turkey and originated a causation from FDI and growth to emissions.

Charfeddine and Khediri (2016) explored the EKC in Qatar from 1975 to 2011. They validated the EKC in Qatar and instituted a positive impact of trade. Farhani et al. (2014) scrutinized the EKC in Tunisia from 1971 to 2008. They validated the EKC in Tunisia and found a positive effect of trade on emissions. The authors also established causation from income to energy. Lau et al. (2014) explored the EKC from 1970 to 2008 in Malaysia. They found the EKC and corroborated the impact of FDI and trade. Moreover, they found the bidirectional causality of growth with FDI and emission. Shahbaz et al. (2015) explored the EKC in Portugal from 1971 to 2008. They found the EKC in Portugal and also found that urbanization accelerated the emissions. In addition, energy also boosted the emissions in Portugal.

In testing the EKC in Saudi Arabia, literature has explored the relationship between emissions and growth. For instance, Mahmood and Alanzi (2020) argued that Saudi Arabia targeted to reduce fossil fuel dependence. They investigated the income and emissions relationship in Saudi Arabia, controlling the rules of law in the model from 1996 to 2014. The authors instituted a positive impact of energy on emissions, and the rules of law variable helped to reduce the emissions. Mahmood et al. (2020) argued that urbanization was continuously rising in Saudi Arabia from 1980 to 2014, which might have environmental consequences. Hence, they investigated the effects of urbanization on emissions. They found that urbanization accelerated the CO_2 emissions, and oil price was also affected emissions. Alkhateeb et al. (2018) scrutinized the role of FD on emissions in Saudi Arabia from 1971 to 2016. The study instituted a positive impact of FD on emissions, and growth also accelerated emissions in the Kingdom. Mahmood and Alkhateeb (2017) investigated the EKC and role of trade in Saudi Arabia from 1970 to 2016. The EKC was found, and trade was reducing the emissions.

The literature review has shown a variety of studies on the EKC testing in panel and country-wise studies. The EKC studies in Saudi Arabia or related regions showed association between emissions and growth. However, the EKC between growth and energy is missing in Saudi Arabian literature. Hence, we contribute to the energy-EKC literature of the Saudi economy by inspecting the cubic relationship.

3. METHODS

The literature has investigated the energy-EKC between growth and absolute energy relationship (Suri and Chapman, 1998). Hence, we follow the same in the cubic relationship between energy and growth:

$$EC_t = f(Y_t, Y_t^2, Y_t^3) \tag{1}$$

Y_t and EC_t are the natural logarithms of GDP per capita and energy consumption. Data is collected from BP (2021) and World Bank (2021). To ensure the unit root free series, we applied Augmented Dickey and Fuller (ADF) (1981) using equations with different specifications:

$$\Delta w_t = a_1 w_{t-1} + \sum_{i=0}^{q} a_{2i} w_{t-i} + u_{1t} \tag{2}$$

$$\Delta w_t = a_0 + a_1 w_{t-1} + \sum_{i=0}^{q} a_{2i} w_{t-i} + u_{2t} \tag{3}$$

$$\Delta w_t = a_0 + a_1 w_{t-1} + \sum_{i=0}^{q} a_{2i} w_{t-i} + a_3 T + u_{3t} \tag{4}$$

The equations 2-4 would be tested for unit problems in the level and differenced series. Then, we apply the Autoregressive Distributive Lag (ARDL) of Pesaran et al. (2001):

$$\Delta EC_t = b_0 + b_1 EC_{t-1} + b_2 Y_{t-1} + b_3 Y_{t-1}^2 + b_4 Y_{t-1}^3 + \sum_{i=1}^{k1} b_{5i} \Delta EC_{t-i} + \sum_{i=0}^{k2} b_{6i} \Delta Y_{t-i} + \sum_{i=0}^{k3} b_{7i} \Delta Y_{t-i}^2 + \sum_{i=0}^{k4} b_{8i} \Delta Y_{t-i}^3 + e_{1t} \tag{5}$$

$$\Delta EC_t = b_{10} ECT_{t-1} + \sum_{i=1}^{k1} b_{5i} \Delta EC_{t-i} + \sum_{i=0}^{k2} b_{6i} \Delta Y_{t-i} + \sum_{i=0}^{k3} b_{7i} \Delta Y_{t-i}^2 + \sum_{i=0}^{k4} b_{8i} \Delta Y_{t-i}^3 + e_{1t} \tag{6}$$

The equations 5-6 would be utilized for bound testing and calculating long and short-run effects after confirming cointegration.

4. DATA ANALYSES

Before starting formal analysis, Figure 2 shows the scatter plot of Y and EC. The figure shows that the relationship between Y and EC is not linear. The first one-third part of the figure shows a clear positive relationship between Y and EC. The second one-third of the figure shows a slight negative relationship between Y and EC, and the last one-third of the figure shows a positive relationship between Y and EC. Hence, Figure 2 reflects the possible N-shaped relationship between Y and EC. Hence, we move toward the N-shaped energy-EKC testing.

After a visual observation of the growth and energy relationship, stationarity is verified for all series using the ADF test. Table 1 shows the results. EC_t, Y_t, Y_t^2, and Y_t^3 are nonstationary at the level. However, ΔEC_t, ΔY_t, ΔY_t^2, and ΔY_t^3 are stationary after

Figure 2: Scatter plot

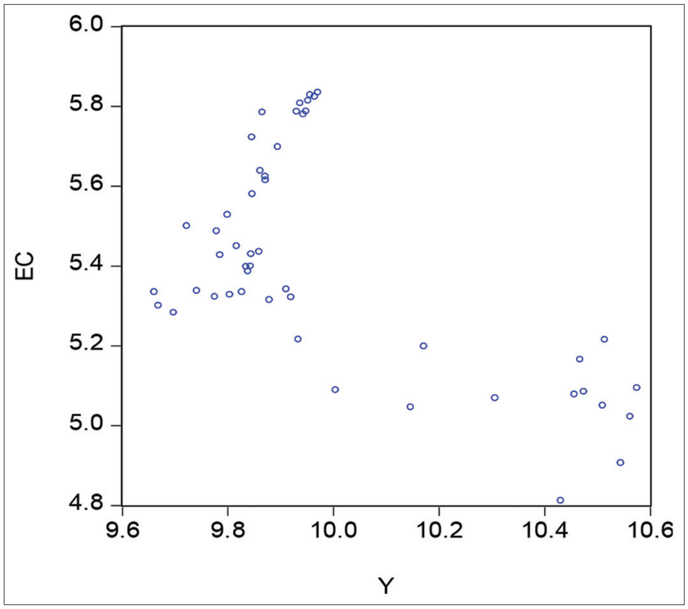


Table 1: ADF test

Variable	Intercept	Intercept and trend	None
EC_t	−0.6492 (0.8494)	−3.1813 (0.1003)	1.9013 (0.9851)
Y_t	−2.2542 (0.1908)	−2.2182 (0.4686)	−0.3494 (0.5538)
Yt_2	−2.2226 (0.2013)	−2.1955 (0.4807)	−0.3913 (0.5377)
Yt_3	−2.1906 (0.2123)	−2.1731 (0.4927)	0.4337 (0.5211)
ΔEC_t	−8.8865 (0.0000)	−8.7846 (0.0000)	−8.4284 (0.0000)
ΔY_t	−5.0784 (0.0001)	−5.0200 (0.0009)	−5.1251 (0.0000)
ΔYt_2	−5.0514 (0.0001)	−4.9920 (0.0010)	−5.0980 (0.0000)
ΔYt_3	−5.0317 (0.0001)	−4.2853 (0.0083)	−5.0783 (0.0000)

Table 2: Bound test

Variable	Statistic	P-value
F-value based on bound test	1.2654	--
Heteroskedasticity test	0.6360	0.4293
Serial correlation	0.6663	0.5191
Normality test	0.6707	0.4968
Ramsey Reset test	1.9686	0.2625
Critical bounds	Lower	Upper
At 10%	2.72	3.77
At 5%	3.23	4.35
At 1%	4.29	5.61

first differencing at a 1%. Hence, order of integration is one in the model of energy-EKC, and cointegration can be applied.

Table 2 demonstrates the bound test result. The F-value from the Wald test is very lower than the lower critical-value at 10%. Hence, it could not prove cointegration in the model.

Table 3 shows the long and short results of N-curve energy-EKC. To discuss the results, cointegration is the precondition, which is not corroborated with the bound test. However, it is confirmed with the negative and significant parameter of ECT_{t-1}. Hence, we discuss the results in Table 3. It displays that the parameters of Y_t, $Y_t^{2,}$ and Y_t^3 are 7071.7270, -700.3940, and 23.1101, respectively. Hence, N-shaped energy-EKC is corroborated in Saudi Arabia. After some mathematical calculations and taking exponent of the results, the first turning point of energy-EKC is 19277 constant US dollar. Hence, GDP per capita before 19277 is increasing energy use in the Kingdom and is responsible for environmental degradation as most energy is utilized from fossil fuel. However, achieving the 19277 level of GDP per capita, the economic growth is decreasing energy consumption and is helpful to reduce environmental degradation in the Kingdom. In the same way, we estimate the second turning point of energy-EKC at 30880. Hence, achieving this level of GDP per capita, the economic growth is again increasing energy consumption and is responsible for environmental degradation because of increasing fossil fuel consumption.

Table 3: Long and short run results

Variable	Parameter	Standard error	t-value	P-value
Y_t	7071.7270	4042.4750	1.7494	0.0874
Yt_2	−700.3940	401.9565	−1.7425	0.0886
Yt_3	23.1101	13.3157	1.7356	0.0898
Intercept	−23782.4000	13544.8900	−1.7558	0.0862
ΔY_t	603.1121	301.2180	2.0022	0.0516
ΔYt_2	−59.7331	29.8744	−1.9995	0.0519
ΔYt_3	1.9709	0.9871	1.9968	0.0522
ECT_{t-1}	−0.0853	0.04208	−2.0266	0.0489

The parameter of ECT_{t-1} is −0.0853 and convergence is corroborated. The parameters of ΔY_t, $\Delta Y_t^{2,}$ and ΔY_t^3 are 603.1121, -59.7331, and 1.9709, respectively. Hence, the N-shaped energy-EKC is also corroborated. Hence, a higher quantity of energy would be expected at a lower level of development in the short run. Later on, a lower energy quantity would be utilized at a higher stage of development. Moreover, the energy demand may also be expected to rise again on the third level of development in the short run. Hence, it confirmed the short run N-curve.

5. CONCLUSION

Fossil fuel usage may have environmental consequences. So, environmental consequences of economic growth might be more dangerous for the countries, heavily depending on fossil fuels. Hence, it is very important to confirm the exact relationship between energy behaviors and growth. This research investigated the energy and growth nexus in Saudi Arabia, assuming a cubic relationship, using a period 1970-2019 and a cointegration test. The unit root analysis confirms the first difference stationarity. We corroborated the cointegration and short-run relationship with the estimated parameters of ECT_{t-1}. The estimated long-run parameters of linear, quadratic, and cubic terms of economic growth are found positive, negative, and positive, respectively. Hence, long run energy-EKC is corroborated in Saudi Arabia. We found the first turning point of the N-curve at 19277 constant US dollar GDP per capita, and the second point is found at 30880. Hence, the increasing GDP per capita lesser than 19277 constant US dollar and greater than 30880 constant US dollar are responsible for higher energy use and would have environmental consequences. Contrarily, the increasing GDP per capita between 19277 and 30880 would decrease energy consumption and have pleasant environmental consequences. Moreover, the same short run behavior of energy consumption is observed with economic growth. Hence, the energy-EKC is also corroborated in the short run.

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