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Renewable, Nonrenewable Energy Consumption, and Economic Growth Nexus: New Evidence from the Malaysian Economy

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ABSTRACT

Purpose: This research explores the relationship between renewable and non-renewable energy consumption and Malaysian economic growth from 1990 to 2014.
Design/ Method/ Approach: We have used the Autoregressive Distributed Lag (ARDL) Bounds test to achieve the primary research objectives.
Findings: The findings revealed a positive and significant relationship between Malaysia's nonrenewable energy consumption, labour force, and RGDP. Malaysia's RGDP has a significant and negative relationship with net financial accounts.
Research limitations: This study examines Malaysian economic time series data from 1990 to 2014.
Practical implications: This study adds new insights into Malaysian renewable and nonrenewable energy consumption and its relationship to economic growth. As a result, empirical findings suggest that the Malaysian government establish adequate subsidies for renewable energy production, such as investment subsidies, tax breaks, credit sequels, and rebates.

1. Introduction

Researchers in the energy economics literature, including Rahman and Rahman and Mamun (2016); Rahman (2017); Ozturk, Aslan, and Kalyoncu (2010), and Apergis and Payne (2012), have extensively explored the causality between energy consumption and sustainable growth, taking into account the high demand for energy, which is also a significant driver of growth, as explained by Hasanov, Bulut, and Suleymanov (2017). However, study results relating to such parameters are frequently inconclusive, indicating a schism among scholars. Many of these studies were undertaken, in particular, to highlight the energy growth nexus based on aggregate energy usage. Apergis and Payne (2011, 2012), Salim, Hassan, and Shafiei (2014); Tugcu, Ozturk, and Aslan (2012) are only a few of the recent studies that investigated the issue using disaggregated energy consumption. These studies are carried out in many parts of the world, including the OECD and the G-7 countries, and the results are consistent; yet, they add to the body of knowledge. According to Ozturk et al. (2010) and Tugcu et al. (2012), the important causes for producing inconsistent results include the adoption of diverse data sources and different statistical tools, as well as the heterogeneous characteristics of countries. Renewable energy produces fewer carbon emissions and is more cost-effective. It has become more common as a result of volatility, high, and unpredictable energy costs, as well as the detrimental impact of fossil fuel emissions on the environment. Solar and wind power rates have dropped dramatically in recent years, boosting the spread of renewable energy. According to IEA (2018) predictions, the renewable energy market is expected to grow by more than 33% until 2022. According to Abbas et al. (2018) and Shukla et al. (2017), energy consumption is beginning to grow in SA countries and other areas of the world as a result of an increase in various construction plans and population expansion. Energy production is in scarce supply in all SA countries due to a significant imbalance between fossil fuel supply capacity and energy demand (Conte & Monno, 2012). A major difficulty is meeting the diverse socio-economic growth ambitions established primarily by the governments of various countries. According to Shukla et al. (2017), renewable energy is a critical choice for South Asian countries to fulfil increasing electricity demand and reduce greenhouse gas emissions, because most of these energy sources, such as wind and the sun, are limitless. Due to the value and expansion of renewable energy, the dynamics of renewable energy and economic growth must be acknowledged in studies on energy economics and the potential of renewable energy. As a result, despite the fact that this is a poorly explored field, this research is aimed towards resolving the problem. According to Kahouli (2017), because there has been insufficient research on the relationship between financial development, energy consumption, and economic growth, this analysis includes a financial development parameter. To the best of my knowledge, no research has been done to evaluate the relationship between these parameters in South Asian countries where renewable growth and economic development are accelerating at breakneck speed.

This research would be an excellent addition to the existing body of knowledge. The following are some of our most significant observations: (I) While most earlier studies focused on the relationship between overall energy consumption and economic growth, this diversity provides a framework for understanding the relative intensity of the growth mechanisms of both types of energy usage; (ii) This is the first analysis of South Asia to be done using the most recent

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data, providing the country's legislators with a large volume of data. (iii) In order to account for the apparent excluded variable bias, this analysis included three additional variables: (iv) because financial production is associated with the economic growth, as suggested by Shahbaz et al. (2013), and this variable is being used as a control variable in the analysis to investigate the competitive energy-growth connection; (v) the study have been using effective panel cointegration to investigate the competitive energy-growth nexus, as suggested by Apergis & Payne (2011) and Salim et al. (2014). To reduce multicollinearity, accurately endogeneity bias, and provide efficient estimates, the study used Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) estimation techniques; and (vii) Dumitrescu & Hurlin (2017) panel causality analysis to identify cross-sectional dependence. The other portions of this paper are organized as follows: Section 2 presents a literature review; section 3 clarifies the model, data, and methodology; section 4 presents the analytical findings; and section 5 concludes the study with practical implications.

2. Literature Review

The literature is broad and evolving, especially since Kraft & Kraft (1978) published a seminal paper on the relationship between energy use and economic progress in the United States. The analysis was carried out in multiple nations around the world over various data spans, using diverse analytical approaches. According to Rahman (2017), academics are pursuing consensus not only on the form of the interactions but also on the causal path between the two variables, as claimed by Ozturk et al. (2010), Rahman (2017), Salim et al. (2014), and Shahbaz et al. (2017). As a result, the amount of time spent studying this issue would grow, which is reasonable.Through core assumptions, Ozturk et al. (2010) and Rahman (2017) investigate the energy-growth relationship. First, the growth hypothesis is predicated on an increase in energy consumption, which boosts economic growth. Second, a common belief holds that the causality between economic growth and energy consumption is unidirectional, so decreasing energy consumption has no detrimental impact on economic growth. Third, the feedback hypothesis implies that energy consumption and bi-directional causality economic growth are interconnected. Fourth, economic development and energy consumption are thought to have no causal relationship, so any one variable policy does not affect the other, as explained by Belke et al. (2011) and Rahman & Mamun (2016).

There are three ways to respond to the research on the relationship between energy usage and economic development. In the first series of investigations, researchers confirmed sustainable theories about the relationship between aggregate energy usage and economic development. For instance, this growth theory has been verified by . Belke et al. (2011), Apergis & Payne (2011, 2012), Nicholas Bowden & Payne (2009), Chontanawat et al. (2008), Narayan & Smyth (2008), and Tang (2010). This study was conducted in a number of nations, including the United States, the OECD, non-OECD, G7, and Vietnam. By contrast, Lise & Van Montfort (2007) studied Turkey using data from 1970 to 2003, while Huang et al. (2008) studied 82 nations using data from 1972 to 2002 to demonstrate the conservative hypothesis' significance in that regard. According to Saidi et al. (2017), the hypothesis is valid for 53 nations, in the instance of Turkey, in the case of Kaplan et al. (2011), and in the case of five European countries, in the case of Fuinhas & Marques (2012). Eggoh et al. (2011) used data from 21 African countries in the region; Belke et al. (2011) used data from 25 OECD countries; and Apergis & Payne (2012) used data from 11 CIS (Commonwealth of Independent States) countries. Several researchers have discovered evidence of mixed ideas coexisting. Soytas & Sari (2006), for example, found evidence of the presence of growth, feedback, and conservative theories in their studies of G-7 countries and ten emerging markets; and Akinlo (2008) and C.-C. Lee (2006) found that the inclusion of feedback, conservation, and neutrality hypotheses is valid in their studies of 11 key industrialist countries and 11 sub-Saharan African countries. Similarly, Apergis & Payne (2012) and Belloumi (2009) proved the collective presence of growth hypotheses for 11 CIS and Tunisia, respectively, while Ozturk et al. (2010) confirmed the input and hypotheses for conservation for 51 states. The second line of research examines the relationship between renewable energy consumption and economic progress. Various hypotheses are also evaluated for their significance by the researchers. According to Chien & Hu (2007), Fang (2011), Payne (2011), and J. A. K. Tiwari (2011), are examples of the presence of a growth hypothesis for India, China, the United States, and 45 states. On the other hand, a conservative hypothesis was found in 18 emerging economies (Sadorsky, 2009). Furthermore, Apergis & Payne (2011) and Menegaki (2011) show that the feedback hypothesis is valid. Third, the study looks into the relationship between energy and growth, separating the effects of energy consumption on economic growth between renewable and nonrenewable energy. The investigations into this new dimension are shown in Table 1. Both of these studies provide contradictory results. For example, Tugcu et al. (2012) and Salim et al. (2014), for example, have demonstrated the validity of feedback theories. However, Apergis & Payne (2011) and Payne (2011) both found validation for the feedback and neutrality hypotheses at the same time. N. Bowden & Payne (2010) discovered the existing development, neutrality, and feedback hypotheses. Furthermore, research conducted by A. K. Tiwari et al. (2015) on either European or Eurasian countries indicates both positive and negative effects on renewable and nonrenewable energy growth. Despite the fact that energy growth is a well-studied topic, the above topic implies that studies that analyse the impact of disaggregated energy usage on economic growth are insufficient, and the results are still contradictory. The results are not quite there yet. Additional research is also required to reduce the energy-growth nexus debate. Furthermore, as far as we know, there

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is no research on the impact of renewable and nonrenewable energy use on economic growth in South Asia. This research would also address the current literature's flaws and lead to the addition of a third dimension.

3. Research Model and Hypotheses

The most recent research shows two different viewpoints on energy-production linkages. The neoclassical growth model arises from the first perspective on the relationship, according to which energy has little or no impact on production, as detailed by Camarero et al. (2015) and Hasanov et al. (2017), but capital and labour do. Technical advancements can still have a huge impact. According to Camarero et al. (2015) and C. C. Lee & Chang (2008), energy was never considered as a factor of production function source by the Harrod, Domar, and Solow-Swan models. According to the opposing viewpoint, energy may be a significant output element, as indicated by Barro (1990) and Hamilton (1983). In Galli (1998) discussion of the growing infrastructure building process, energy, comprising money and manpower, is critical. Following Adams et al. (2018), Gozgor et al. (2018), Hasanov et al. (2017), and Ozturk et al. (2010), we are developing a primary production function that applies a country's inputs to its output. Our model is based on the Cobb-Douglas development function's conceptual framework.

$$Y = K^{\alpha} L^{\beta} e \qquad \ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

Where 'Y' is output, 'K' and 'L' signify capital and labour. The terms 'α' and 'β' are revealing efficiencies of capital (K) and labour (L) respectively. While, 'e' is the errors-term that comprehends all other non-observed production parameters.

$$Y = K^{\alpha}.L^{\beta}.(ReEn)^{\gamma}(NReEn)^{\omega}.e \ldots\ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

Wherever 'Y' is growth or output, 'K' and 'L' signify capital (net financial accounts) and labor (total labor force) respectively used in production; 'e' is the errors-term that comprehends ultimately further non-observed production parameters. In line with the above studies, our model has been expanding to include renewable (ReEn) and nonrenewable energy (NReEn) consumption as desired output parameters in a multivariate framework.

For the Malaysian economy, we compiled annual time-series data from the World Bank's World Development Indicators (WDI) database from 1990 to 2014. Statistics on nonrenewable energy consumption would be difficult to come by at the WDI. To measure nonrenewable energy consumption by country and year, we collect data from the database for three separate variables: renewable energy consumption per capita, energy consumption in kg oil equivalent per capita, and population. We derive total energy consumption in kilogrammes of oil equivalent by multiplying energy consumption in kilogrammes of oil per capita and total population (renewable and nonrenewable). A multiplication equals total energy consumption per kilogramme of oil, and a division by 100 kilogrammes is the percentage of renewable energy consumption in kilogrammes of oil. This study is based on energy consumption (kg oil equivalent per capita) and a GDP of year 2000 (real GDP). The range of the starting period was limited by the availability of energy usage statistics. The composition is due to the use of nonrenewable energy (total energy consumption - total renewable energy consumption). The total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship, while net financial accounts (BoP current US $) are implied as a proxy for capital. As a proxy for labour, the values provided are midyear estimates. Hence,

$$Total\ Renewable\ Energy = \left(\frac{\begin{matrix}(Total\ energy\ consumption)\ X \\ Renewable\ energy\ consumption \\ (expressed\ as\ \%\ of\ total\ energy\end{matrix}}{100} \right)$$

The total energy consumption of nonrenewable energy is calculated as total energy consumption minus total energy consumption of renewable energy. The following mathematical methodology is used to calculate per capita renewable energy use and nonrenewable energy consumption:

4. Results and Discussions

4.1 Unit Root

This study involved ADF (Augmented Dickey-Fuller) unit root tests, including the Augmented Dickey and Fuller (ADF) and Phillips and Perron (PP), to ensure the robustness of critical elements of renewables and nonrenewable energy use, real GDP, labor force, and net financial accounts. Findings demonstrate that all the variables stationary at I(1).

Table: 1 Unit Root Test Results

	Augmented Dickey-Fuller	
	I(0)	I(1)
RGDP	0.3311	0.0026
Renewable energy consumption	0.2172	0.0195
Nonrenewable energy consumption	0.1022	0.0003
Net financial accounts	0.0031	-

https://dx.doi.org/10.30566/ijo-bs/2022.07.92

Labor force	0.7845	0.0007

According to the above unit root test outcomes (table A), all variables are stationary at the first difference – I(1) expect net financial accounts which is stationary at level – I(0), which directs to applying ARDL techniques for short-run and long-run analysis.

4.2 Johansen Cointegration Analysis

Table: 2 Unrestricted Cointegration Rank Test (Trace) and Unrestricted Cointegration Rank Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5% Critical Value	Prob.**
None *	0.969577	145.0641	69.81889	0.0000
At most 1 *	0.767594	64.73566	47.85613	0.0006
At most 2 *	0.590176	31.17247	29.79707	0.0345
At most 3	0.358934	10.65586	15.49471	0.2336
At most 4	0.018502	0.429524	3.841466	0.5122
Trace test indicates 3 Cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	5% Critical Value	Prob.**
None *	0.969577	80.32844	33.87687	0.0000
At most 1 *	0.767594	33.56319	27.58434	0.0076
At most 2	0.590176	20.51661	21.13162	0.0608
At most 3	0.358934	10.22634	14.26460	0.1975
At most 4	0.018502	0.429524	3.841466	0.5122
Max-eigenvalue test indicates 2 Cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Table 4.2 demonstrated the Johansen cointegration results. According to the 'Trace' test, 3 cointegrated equations revealed at a 5% level of significance, while the 'Max-eigenvalue' test reveals 2 cointegration equations. Hence, cointegration does exist.

4.3 Error Correction Model (ECM) Results

Table: 3 ECM Regression and F Bound Test Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CointEq(-1)*	-0.678318	0.053163	-12.75921	0.0000
R-squared	0.620089	Mean dependent var		0.056088
Adjusted R-squared	0.602820	S.D. dependent var		0.038691
Durbin-Watson stat	2.429624			
* p-value incompatible with t-Bounds distribution.				
F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	20.96633	10%	2.2	3.09
k	4	5%	2.56	3.49

Multiple time series models estimate the speed at which a dependent variable. Returns to balance after a shift in independent variables comprise renewable energy consumption, nonrenewable energy consumption, net financial accounts, and the labor force is known as Error correction models (ECMs), for instance, speed of adjustment. According to table C, CointEq(-1) revealing significant and negative coefficient values expressed that adjustment is towards the equilibrium position. F-Bounds test confirms the long-run relationship among the variables considered in any model. According to the F-Bounds test, the F-statistic value stated more than the lower I(0) and upper I(1) limit at a 5% level of significance.

4. 4 Long-run and Short-run ARDL Results

Table: 4 ARDL Short-run and Long-run Outcomes

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.116017	1.769471	-0.065566	0.9485
Renewable Energy Consumption	-0.002131	0.084978	-0.025082	0.9803
Nonrenewable Energy Consumption	0.305427	0.145646	2.097058	0.0513

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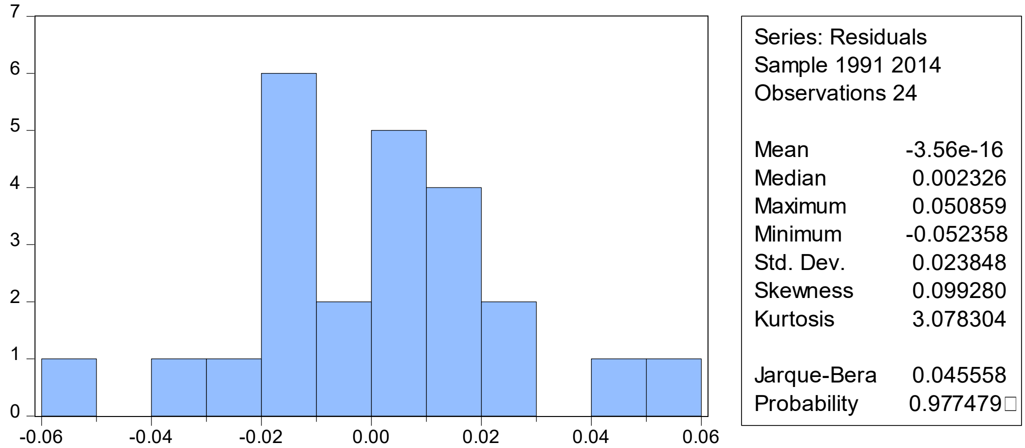
Net Financial Accounts	-0.006671	0.001999	-3.336363	0.0039
Labor Force	0.641006	0.220527	2.906707	0.0098
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Renewable Energy Consumption	-0.003142	0.125161	-0.025105	0.9803
Nonrenewable Energy Consumption	0.450272	0.193079	2.332058	0.0323
Net Financial Accounts	-0.009835	0.002785	-3.530782	0.0026
Labor Force	0.944994	0.254180	3.717813	0.0017
C	-0.171036	2.612229	-0.065475	0.9486
RGDP = - 0.1710 - 0.0031(Renewable Energy Consumption) + 0.4503 (Nonrenewable Energy Consumption) - 0.0098(Net Financial Accounts) + 0.9450 (Labor Force)				

There are two sections in table D, including short-run and long-run ARDL analysis results. The labour force and RGDP have a large and positive association in the short run. It states that adding a unit to the work force will boost Malaysia's RGDP by 0.64 unit. Growing one unit in the net financial account suited the progressive drop in RGDP by 0.0066 units, revealing a significant but negative link between net financial accounts and RGDP. Nonrenewable energy consumption and the labour force have a large and favourable relationship with Malaysia's RGDP in the long run. According to the empirical results, increasing one unit of nonrenewable energy consumption and labour force in Malaysia resulted in 0.45 and 0.94 unit increases in RGDP, respectively. During this time period, net financial accounts exhibit a substantial and negative relationship with Malaysia's RGDP, indicating that increasing one unit in net financial accounts causes a 0.009 unit decline in the Malaysian economy's RGDP.

4.5 Residual Diagnostics Tests

Figure: 1



According to Fig. I, the observation and histogram revealing the existence of normality in our data.

Table: 5 Diagnostic Test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	1.623190	Prob. F(1,16)	0.2208
Obs*R-squared	2.210528	Prob. Chi-Square(1)	0.1371
Heteroscedasticity ARCH Test			
F-statistic	0.147324	Prob. F(1,21)	0.7050
Obs*R-squared	0.160231	Prob. Chi-Square(1)	0.6889

CUSUM and CUSUM Square Tests

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Figure: 2

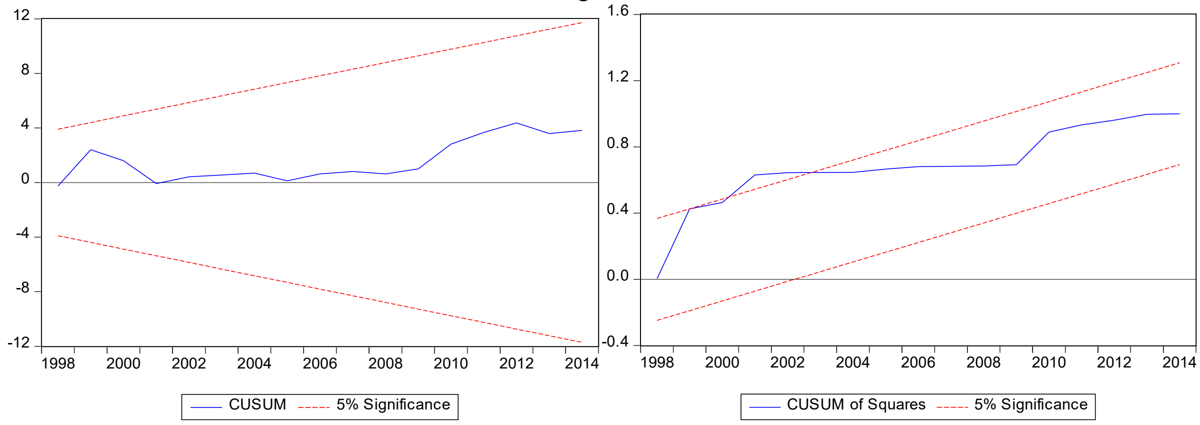

Fig.II representing CUSUM and CUSUM square test, which direct that our model is fit and all outcome estimations and satisfactory.

5. Conclusion

The goal of the study is to use an augmented neoclassical economic growth model to investigate the effects of renewable and non-renewable energy consumption on Malaysian economic growth. Annual time series data from the World Bank data bank were used for estimation and analysis from 1990 to 2014. The findings reveal a significant and positive association between non-renewable energy use and labour force and Malaysia's RGDP. According to the outcomes, increasing one unit of nonrenewable energy consumption and labour force in Malaysia resulted in 0.45 and 0.94 unit increases in RGDP, respectively. Furthermore, net financial accounts have a significant and negative relationship with Malaysia's RGDP, indicating that raising one unit in net financial accounts will lead the Malaysian economy's RGDP to drop by 0.009 units in the long run. The policy implication of the reported results is that Malaysian authorities must raise both renewable and non-renewable energy consumption in the immediate term. The Malaysian government, on the other hand, has to boost renewable energy consumption more effectively than non-renewable energy consumption in the long run. It is now proposed that the Malaysian government give adequate incentives for renewable energy production, such as investment subsidies, tax benefits, installation on credit, and refunds. Furthermore, policymakers must proceed with appropriate measures with necessary public and private partnerships to ripen and comfort the market approachability of renewable energy and capital inducement technology. These incentives and activities can encourage clean energy and modernise the energy section outlined by Apergis & Payne (2011) in order to achieve long-term economic growth and development.

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