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The Impact of Electricity Consumption on Economic Growth in Malaysia: Evidence from ARDL Bounds Testing

(Kesan Penggunaan Elektrik kepada Pertumbuhan Ekonomi di Malaysia: Bukti dari Pemeriksaan 'ARDL Bounds')

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ABSTRACT

This paper investigates the relationship between electricity consumption and economic growth in Malaysia during the period 1971-2014. The results from the ARDL bounds testing approach, as developed by Pesaran et al. (2001), showed that there was a cointegration between electricity consumption and real Gross Domestic Product (GDP). There was also a stable long-run relationship between other determinants such as foreign direct investment (FDI) and real GDP. Moreover, we found that electricity consumption, FDI, and real capital positively affected economic growth in the short-run. Therefore, it is recommended that policies should be geared towards improving current energy production and encouraging the exploration of alternative energy sources in order to promote growth in the Malaysian economy.

Keywords: Electricity consumption; economic growth; Auto-Regressive Distributed Lag

ABSTRAK

Kertas penyelidikan ini menyiasat hubungan di antara penggunaan elektrik dan pertumbuhan ekonomi di Malaysia dalam tempoh 1971-2014. Hasil dari pendekatan pemeriksaan 'ARDL bounds', seperti yang dibangunkan oleh Pesaran et al. (2001), menunjukkan bahawa terdapat kointegrasi di antara penggunaan elektrik dan pertumbuhan ekonomi. Terdapat juga hubungan jangka panjang yang stabil di antara penentu-penentu lain seperti pelaburan langsung asing (FDI) dan pertumbuhan ekonomi. Tambahan lagi, kami mendapati bahawa penggunaan elektrik, FDI, dan modal sebenar mempengaruhi pertumbuhan ekonomi dalam jangka pendek. Oleh itu, adalah disyorkan supaya dasar-dasar harus ditujukan untuk meningkatkan pengeluaran tenaga semasa dan menggalakkan penerokaan sumber-sumber tenaga alternatif untuk menggalakkan pertumbuhan ekonomi Malaysia.

Kata kunci: Penggunaan elektrik; pertumbuhan ekonomi; Auto-Regressive Distributed Lag

INTRODUCTION

Studies related to the relationship between the energy and GDP nexus using the multivariate framework are still growing, particularly, for emerging countries, according to Lean and Smyth(2010). Emerging countries consume more energy in order to achieve their potential economic growth; which indirectly leads to a rise in carbon dioxide emissions that can cause global warming and compromise the biosphere. Malaysia, as one of the emerging and developing countries, has also seen an increase in the level of energy consumption and growth in its Gross Domestic Product (GDP) over the years (refer to Figure 1). The significance of studying the relationship between energy consumption and economic growth is that it can provide valuable information to policymakers when creating and establishing a suitable policy concerning this matter. If the right policy is to be implemented, this will bring Malaysia closer towards realising its Vision 2020 in which the country aims to become a high-income country.

Many academics argue about the relationship between energy consumption and economic growth. According to Ozturk (2010), many studies could be used as references in terms of the methodologies, sample periods and countries related to this subject. The originators of this idea were Kraft and Kraft (1978), where they found that there was a unidirectional causality between energy consumption and the Gross National Product (GNP). However, this finding was strongly opposed by Akarca and Long (1980) after a re-examination of the relationship. According to Islam et al. (2013), the nexus between energy consumption and economic growth had been extensively studied by academicians over the past few decades. However, the existence of empirical evidence on the relationship, in general, and the direction of the causality have not provided convincing results. Fundamentally, economists and environmentalists

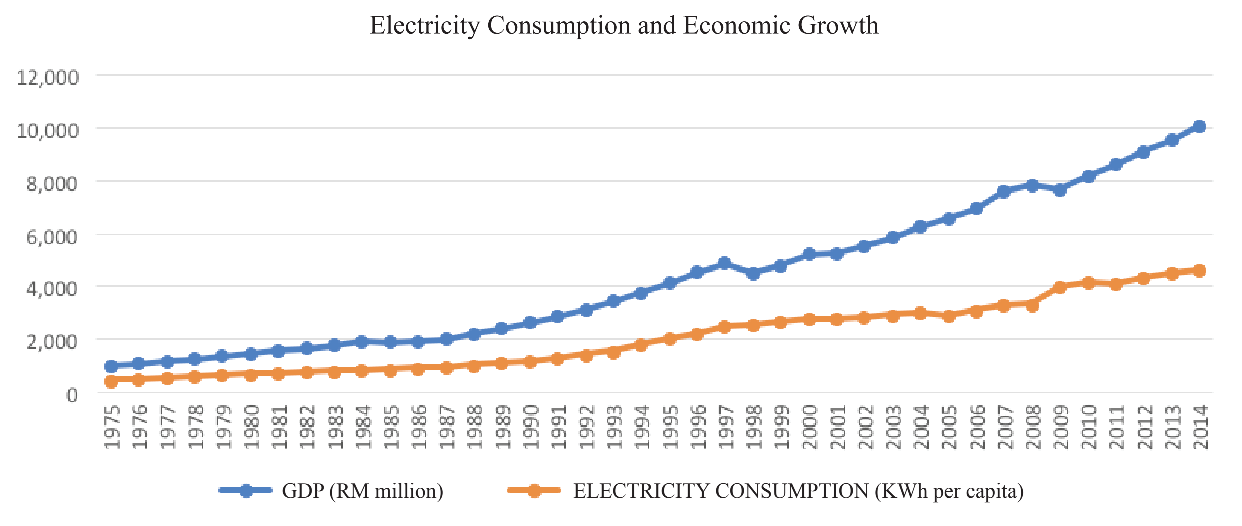


FIGURE 1. Electricity Consumption and Economic Growth, 1975-2014
Sources: World Bank Data

attempt to determine whether economic growth causes energy consumption or energy consumption causes economic growth or both. Understanding the direction of the causality for policymakers is necessary and important in order to formulate policies for energy and economic growth to ensure the sustainability of economic development.

As one of the fastest growing open economies among developing countries, Malaysia can attract more foreign investment and increase its energy consumption in the country (Aliyu & Ismail 2015). Therefore, the subject of energy consumption and its impact on the economy is of interest for further exploration. This study is motivated by the fact that there is the possible existence of a cointegration or a long-run relationship between electricity consumption and real GDP.

From Figure 1, it can be observed that electricity consumption has increased together with the growth in GDP from 1975 to 2014. This suggests a potential (stable) relationship between electricity consumption and real GDP.

There are four causal hypotheses related to this relationship: (1) the neutrality hypothesis; (2) the feedback hypothesis; (3) the growth hypothesis; (4) the conservation hypothesis. Briefly, the neutrality hypothesis states that there is no causal relationship between energy consumption and economic growth. The feedback hypothesis supports a unidirectional causality running from economic growth to energy consumption and the growth hypothesis supports a unidirectional causality running from energy consumption to economic growth. The fourth hypothesis, the conservation hypothesis, states that the relationship is actually bi-directional.

In relation to the direction of the causality, the Granger causality method, first introduced by Granger (1960) has been extensively to understand the relationship, not only in the case of energy consumption and economic growth (Lean & Smyth 2010) but also for other variables of interest. However, studies that use the Granger causality tend to suffer from omitted variables bias. According to Tang and Tan (2013), bivariate studies are more likely to suffer from omitted variables bias. This is because the bivariate framework is likely to form a biased result, an effect of the omission of relevant variables that have an impact on energy consumption and economic growth. On the other hand, there are studies that examine the relationship between economic growth and energy consumption by also including other relevant variables such as employment, exports, urbanisation, capital or labour, and pollutant emissions (Lean & Smyth 2010). According to Azlina (2012), the tendency, by previous studies, to ignore the role of energy in the demand and supply side by not including important variables such as labour, energy prices and capital stock has led to misleading results. Moreover, there are also some studies in Malaysia that have produced contradictory results. For example, Loganathan and Subramaniam (2010) showed that there is a bi-directional causality running between energy consumption and economic development while Ang (2008) stated that there was a uni-directional causality running from economic development to energy consumption. Therefore, the results obtained opposed one another, proving that one should be cautious when drawing policy implications.

The Johansen and Juselius (1990) method is frequently used to study cointegration relationships between variables of interest. This method is more efficient in the multivariate system. Some of the studies that have applied this method include Mahadevan and Asafu-Adjaye (2007), Zhang and Cheng (2009), Tsani (2010) Marques et al. (2014) and etc. On the other hand, the Autoregressive Distributed Lag (ARDL) method has several advantages over these other approaches. First, despite small sample size, it can determine the cointegration more efficiently (Ghatak & Siddiki 2001). Secondly, if there is a problem with the non-stationary time series data it can overcome the problem (Laurenceson & Chai 2003). It is also able to integrate I(0) or I(1) series or mix the order of integration. The ARDL approach also does not require pre-testing for the presence of a unit root but we must make sure that there is no I(2) in any of the variables. Moreover, the ARDL procedure allows the variables to have optimal lags for a causal relationship between the variables. According to Harris and Sollis (2003), we can obtain unbiased estimates of the long-run by using the ARDL approach.

Bekhet and Othman (2011) examined the relationship between energy consumption and several variables such as price, employment, economic growth, and FDI. In energy-growth literature, economic growth is influenced by FDI (Tang et al., 2016)energy consumption, FDI and capital stock were found positively influence economic growth in Vietnam. The Granger causality test revealed unidirectional causality running from energy consumption to economic growth. Hence, Vietnam is an energy-dependent economy and any energy or environment policy drawn up in an attempt to conserve energy will jeopardise the process of economic development in Vietnam. For this reason, the renewable energy policy should be given attention to provide sufficient supplies of energy to speed up economic expansion. Investment in R&D may be required to incentivise private/public institutions to engage in this innovation, while the awareness for energy-saving policy among public could be integrated to meet social economic development. Tang et al. 2016. Thus, this makes FDI one of the most important variables to economic development. There is a belief among researchers that FDI generates productivity externalities for host countries. FDI can increase the energy efficiency of the country by reconstructing technology transfer, production, et cetera (Alfaro et al. 2010). Furthermore, Kazemi and Azman-Saini (2017), stated that FDI inflow increases with democratic institutions. There is also a belief by Masron and Nor (2016) that FDI also supports development for host countries. Therefore, considering this, our study also includes FDI as one of the determinants of economic growth.

Studies using the multivariate framework in the energy-GDP nexus are still limited in Malaysia. Thus, it is crucial for related studies in Malaysia to re-examine the relationship between energy consumption and economic growth. This study examines the relationship between electricity consumption and other determinants that include FDI, capital, and economic growth by applying the approach of ARDL bounds testing.

LITERATURE REVIEW

The originators of the topic of energy consumption and economic growth were Kraft and Kraft (1978). They examined the causal relationship between energy consumption and economic growth. The results of the study may have been different if they had been carried out in different countries, over different periods, using different proxy variables as well as using different methodologies. The results from such studies may vary and are sometimes complicated. The results may also show a different long-term and short-term impact on energy policies and in terms of causality (Ozturk 2010). It is crucial for policymakers to understand the link between these two variables because energy implications depend on the type of relationship. The outcome from these two variables is important in order to decide whether economic growth promotes energy consumption or energy consumption results in economic growth or if there is no causal relationship between them (Bartleet & Gounder 2010).

Knowledge about whether a significant relationship exists between economic growth and energy consumption is important in the design and implementation of environmental and energy policies. There is existing literature that offers a large range of models to study the relationship between energy consumption and economic growth or the energy-growth nexus. The outcomes from the relationship between energy consumption and economic growth are divided into four hypotheses, namely, the feedback, conservation, growth and neutrality hypotheses (Ozturk 2010).

The first group reports that there is no causal relationship between these two variables. It is also referred to as the neutrality hypothesis. It is assumed that energy is neutral to growth. Besides that, it indicates that there is no Granger causality between energy consumption and economic growth. According to Belloumi (2009), the reason for the neutral impact of energy on economic growth is that the cost of energy is insignificant. Thus, there is no significant impact on economic growth. There is also an argument that the possible impact of energy consumption on growth depends on the structure of the economy and the level of economic growth of the country concerned. As the economy grows, there is likely to be a shift of sectors from the production to the service sectors, which is less dependent on energy (Solow 1974; Cheng 1995). Anhal (2013) found that there was no causality between GDP and energy consumption in India. Dogan (2014) which used panel data also supported this finding. The study found that countries such as Benin, Congo and Zimbabwe had no causality from 1971 to 2011.

The second group supports the conservation hypothesis. It states that economic growth controls energy consumption. In other words, if there is a unidirectional causality running from economic growth to energy consumption, then this hypothesis is confirmed. In this case, it can be implied that energy conservation policies that may be implemented will have a few adverse effects or no effect at all on economic growth (Paul and Bhattacharya, 2004). In addition, Cheng and Lai (1997) stated that in general, for newly industrialised countries, energy is crucial for their economic development. Production in industries such as manufacturing, construction, and transportation demands a large amount of energy for which an increase in energy consumption should be expected. Kraft and Kraft (1978) were the originators of this study. Their study examined the causality relationship between GNP and energy consumption by using causality tests from 1947 to 1974 in the US. The results showed that there was a causality running from GNP to energy consumption. Cheng and Lai (1997) who investigated the Granger causality between energy consumption and economic growth in Taiwan by using Hsiao's Granger causality also supported these results. The results confirmed the acceptance of the conservation hypothesis. There was also a study in Ghana by Adom (2011) using Toda and Yamamoto's causality test from 1976 to 2000. This study investigated the direction of causality between electricity consumption and economic growth. The results found that there was a causality running from economic growth to energy consumption.

The third group supports the growth hypothesis. It is claimed that energy consumption has important roles in economic growth, both as a direct input in the production process and indirectly as a complement to labour and capital inputs. A unidirectional causality running from energy consumption to economic growth is consistent with the growth hypothesis. We can say that energy is a limiting factor to economic growth and that the economy is energy dependent. In this case, if energy conservation policies demand that energy consumption should be reduced, it will negatively affect economic growth or cause poor economic growth. According to Binh (2011), policymakers must pursue conservation energy policies that aim for environmentally friendly energy use without affecting economic growth. Furthermore, Ozturk (2010) stated that energy consumption is crucial in economic growth especially in the production process by which it functions as a complement to labour and capital. Thus, we can say that energy is the limiting factor to economic growth. Hence, if energy is jeopardised, it will negatively impact economic growth. Shiu and Lam (2004) investigated the causality between real GDP and electricity consumption in China by using the Granger causality. They found that electricity consumption caused economic growth. Soytas et al.(2007) studied the correlation between disaggregated energy consumption and real GDP in the US. By using a generalised variance decomposition approach in the analysis, the study found that renewable energy consumption explained the small variation in the output. Later on, Eddrief-Cherfi and Kourbali (2012) employed the threshold cointegration causality analysis in Algeria to examine the energy consumption-growth nexus. The results showed that there was a unidirectional causality running from energy consumption to GDP. The same study was also carried out by Chandran et al. (2010). He used an ARDL analysis to measure the causality relationship of the same variables,using Malaysia as a sample country,the results were the same.

Finally, the fourth group supports the feedback hypothesis. It is assumed that energy consumption and economic growth complement each other and simultaneously affect one another. This shows that there is a bi-directional causality. According to Saatci and Dumrul (2013), policymakers should note the feedback effect of real GDP on energy consumption especially when regulations about energy are to be put into action. In contrast, energy consumption should be separated from economic growth to avoid any negative impact from the reduction of energy use on economic development. Furthermore, policymakers should take into account a shift from less efficient energy sources to more efficient and less polluting options that will not compromise economic growth (Belke et al. 2011). Belloumi (2009) conducted a study to test the causal relationship between energy consumption and GDP in Tunisia by applying the Johansen Cointegration between1971 and 2014. The empirical investigation showed that there was a bi-directional causality between energy consumption and economic growth. The same empirical exercise was undertaken by Shahbaz et al.(2012) in which a causal relationship between renewable energy and economic growth in Pakistan was found by using ARDL cointegration. The estimated results supported the acceptance of the feedback hypothesis. Hamdi et al. (2014) used ARDL cointegration in Bahrain. The study found that there was a bi-directional causality between electricity consumption and economic growth.

According to Tang (2009), the influx of FDI influenced energy consumption through the expansion of the transportation, industrial and manufacturing sectors. Additionally, FDI allowed businesses to access financial capital more easily, which could be used to construct new factories and plants. Thus, FDI could possibly increase the demand for energy (Sadorsky 2010). In Malaysia, Tang (2009) examined the causality relationship between electricity consumption, income, population, and FDI. He used the ECM and the Granger causality to test the causality for the period 1970 to 2005. The results found that there was a bi-directional causality between electricity consumption, income, and FDI in the short-run. Furthermore, Bekhet and Othman (2011) found that there was a cointegration and it indicated a long-run causal relationship between electricity consumption and FDI. In this study, we used the ARDL approach to study the relationship between the variables.

DATA AND METHODOLOGY

In this study, we examined the connection between electricity consumption and economic growth by using a multivariate framework. The model used was adapted by using a previous model created by Hamdi et al. (2014). The model was constructed from the Cobb-Douglas production function because it will support the supply side factors on gross domestic production. The general form of production is given below:

$$Y = AK^{\alpha}L^{\beta}e^{u}$$

where Y is real GDP, A represents technology, while K and L indicate real capital and labour respectively.

Furthermore, the authors re-stated the model by assuming that FDI and electricity consumption are represented as technology. Moreover, FDI supports the development of technology and its diffusion.

The model is as follows:

$$Y_t = f(EC_t, FDI_t, K_t) \quad (1)$$

where, Y_t, is real GDP per capita (constant Local currency unit), EC_t, is electricity consumption (kWh per capita), FDI_t is foreign direct investment (Balance of payments, current US$) and K_t is real capital (current local currency unit).

All of the variables are transformed into natural logarithms. The model is as follows:

$$lY_t = B_0 + B_1\, lEC_t + B_2\, lFDI_t + B_3\, lK_t + \varepsilon_t \quad (2)$$

This study was conducted over the period 1971 to 2014 using data with an annual frequency. Thus, the total number of observations made was 44. All data were collected from the World Bank[1].

The first step in the empirical analysis was to check for the stationarity of the variables. A series is stationary if its mean and covariance are independent of time properties. In other words, the series is free from any carry over-effects from the past. Contrarily, if the series carries effects from the past, they tend to be non-stationary. If the series becomes stationary only after being differentiated d times; the series is said to be integrated of order d, I(d). Testing for the variables' stationarity is compulsory in order to avoid any problem with a spurious regression and to ensure the reliability of the regression's result. This study employed traditional unit root tests such as the Augmented Dickey and Fuller (ADF) and the Phillips-Peron (PP) tests. The tests were conducted at the level and first difference using the ADF and the PP tests. The hypotheses for the unit root tests i.e. ADF and PP are given below:

H_0: The series contains unit root i.e. non-stationary
H_a: The series does not contain unit root i.e. stationary

There are conditions that need to be fulfilled by the variables. The conditions are that the variables have to be stationary at order 0 and/or i.e. I(0) and/or I(1), but not I(2).

Next, we employed the Auto-Regressive Distributive Lag (ARDL) bounds test. This test was proposed by Pesaran and Shin (1999) and was further elaborated by Pesaran et al. (2001). This approach is built from the Ordinary Least Squares (OLS) estimation of the conditional Unrestricted Error Correction Model (UECM). The ARDL bounds test can be derived as follows:

$$\Delta \text{In} Y_t = \alpha_1 + \alpha_T T + \alpha_\gamma \text{In}\, Y_{t-1} + \alpha_{EC}\, \text{In}\, EC_{t-1} + \alpha_{FDI}\, \text{In}\, FDI_{t-1} + a_k\, \text{In}\, K_{t-1} + \sum_{i=1}^{p} \alpha_i\, \Delta\text{In}\, Y_{t-1} + \sum_{j=0}^{q} \alpha_j\, \Delta\text{In}EC_{t-j} + \sum_{k=0}^{r} \alpha_k\, \Delta\text{In}FDI_{t-k} + \sum_{i=0}^{s} \alpha_1\, \Delta\text{In}K_{t-1} + \mu_t \quad (3)$$

where Δ is the difference operator and μ_t is the error term which is assumed to be independently and identically distributed. The presence of integration is traced by restricting all estimated coefficients of the lagged level variables equal to zero.

The null hypothesis for the bounds test is the absence of a long-run relationship while the alternative hypothesis is the presence of a long-run relationship. The F-statistic test is used in order to determine whether there exists a long-run relationship or not. There are two set critical values that can be used to determine the long-run relationship i.e. the lower critical bounds, I(0) and the upper critical bounds, I(1). By using the guidelines from Pesaran et al. (2001), if the computed F-statistic is higher than the critical value for the upper bound, there is a long-run relationship. However, if the F-statistic is below the lower bound then there is no long-run relationship. On the other hand, if the F-statistic is between the upper critical bound and the lower critical bound the results are inconclusive. Diagnostic tests were performed to determine the robustness of the model. The tests were the serial correlation test, heteroscedasticity test, normality test and the Ramsey-Reset test. The stability of the model was also tested by using the CUSUM and CUSUMSQ tests.

RESULTS AND DISCUSSION

Table 1 shows the descriptive statistics and the correlation matrix. From the Jarque-Bera test, the results show that all of the variables were normally distributed. In addition, from the results of the pairwise correlation, we can see that real GDP and electricity consumption were correlated positively.

In order to test for the stationarity of the variables, there were two tests that were implemented in this study i.e. the Augmented Dickey Fuller (ADF) and Phillips Perron (PP) unit root tests. Table 2 displays the results. We found that by using the ADF and PP tests that LGDP, LEC and LK were not stationary at level for constant with trend. We found that all of the variables were integrated at I(1) except for LFDI which was I(0). Thus, it was confirmed that there was an absence of I(2) and that the ARDL cointegration was a suitable approach.

TABLE 1. Descriptive statistics and correlation matrix

Variable	LGDP	LEC	LFDI	LK
Mean	26.4497	7.2537	21.2611	24.4597
Median	26.5207	7.2961	21.5326	24.8223
Maximum	27.6434	8.4330	23.4392	26.3842
Minimum	25.0187	5.7466	18.4207	21.7974
Std. Dev.	0.78672	0.8298	1.3833	1.2733
Skewness	–0.1731	–0.2101	–0.3756	–0.4258
Kurtosis	1.7506	1.6980	2.1048	2.0982
Jarque-Bera	3.0816	3.4316	2.5038	2.8208
Probability	0.2142	0.1798	0.2859	0.2440
Sum	1163.788	319.1641	935.4868	1076.229
Sum Sq. Dev.	26.6141	29.6091	82.2843	69.7129
Observations	44	44	44	44
LGDP	1.0000			
LEC	0.9971	1.0000		
LFDI	0.7992	0.7820	1.0000	
LK	0.9856	0.9816	0.8376	1.0000

TABLE 2. Unit root tests

Variables	ADF Test		PP Test		Decision
	Level	1st Difference	Level	1st Difference	
LGDP	–1.6118	–5.6959***	–1.6971	–5.6993***	I(1)
LEC	–2.3186	–3.4268*	–1.2417	–5.5710***	I(1)
LFDI	–5.1949***	–3.1874	–5.1949***	–18.6369***	I(0)
LK	–2.9264	–4.4959***	–2.4107	–4.4619***	I(1)

Note: *, **, and *** denotes a rejection of the null hypothesis at the 10%,5% and 1% significance levels.

In order to confirm the existence of cointegration, the ARDL bounds test was used in this study.The bounds test was used to examine the joint F-statistic of the coefficients on the one period lagged level of the variables where their asymptotic distribution was non-standard under the null hypothesis of no cointegration. To get the joint F-statistic, the ARDL bounds approach must estimate the equations by Ordinary Least Squares (OLS). Since the data used were 44 observations, the Schwarz Bayesian Criterionwas used in this study. Table 3 shows that the F- statistic exceeded the critical value at 1% (12.62>6.61). This implied that there was a rejection of H_0 of no cointegration or long-run relationship for the model tested. Thus, this indicated that there existed a cointegration between electricity consumption, FDI, and capital with the real GDP.

Table 4 shows the evidence of cointegration between electricity consumption, FDI, and capital with the real GDP. The results indicate that electricity consumption was positively and statistically significantly related to real GDP at the 1% significance level. This shows that a 1% increase in electricity consumption will increase real GDP by 0.7418% in the long term. The results are

TABLE 3. Bounds test

Bounds testing to cointegration		
F-Statistics	12.6212***	
Cointegration	Yes	
ARDL	ARDL(2, 4, 1, 1)	
Maximum Lag	4	
Diagnostic tests		
R^2	0.9080	
Adj-R^2	0.8719	
D.W. test	1.9372	
Significant Level	Critical Values	
K=3	Lower Bounds I(0)	Upper bounds I(1)
1% level	5.0180	6.6100
5% level	3.5480	4.8030
10% level	2.9330	4.0200

Note: *,**, *** represent the 10%, 5% and 1% levels of significance

TABLE 4. Long-run and short-run ARDL

Dependent variable = ln GDP_t		
Variables	Coefficient	T-statistic
Long-run model	ARDL(2, 4, 1, 1)	
Constant	18.2186***	25.1373
LEC_t	0.7418***	9.3177
$LFDI_t$	0.1229***	3.3658
LK_t	0.0202	0.3017
Short-run results		
Constant	4.3337***	4.0736
$\Delta LGDP_{t-1}$	–0.3327***	–3.6423
ΔLEC_t	0.3690***	4.7237
ΔLEC_{t-1}	0.1014	1.0408
ΔLEC_{t-2}	0.2126**	2.5529
ΔLEC_{t-3}	–0.3067***	–4.5953
$\Delta LFDI_t$	0.0189***	5.3405
ΔLK_t	0.1700***	7.8287
ECM_{t-1}	–0.2378***	–4.0281

Note: *,**, *** represent the 10%, 5% and 1% levels of significance

aligned with Loganathan and Subramaniam (2010) and Azlina (2012). It should be noted that these studies used different measures of energy. According to Chandran et al. (2010), this showed that Malaysia is an energy-dependent country. This is because the high demand for electricity is parallel to Malaysian's economic policy,Vision 2020, of becoming an industrialised and developed country. Hence, if there are any changes to the energy supply or energy policies, the country's development will be affected. Most studies reveal that there is a positive relationship between electricity consumption and economic growth in Malaysia; higher electricity consumption leads to higher economic growth.

In addition, the coefficient of LFDI is also positive and statistically significant at 1%. This indicates that FDI has a positive relationship with real GDP. However, the relationship between LGDP and LK is not significant. Thus, LK does not have any significant influence on real GDP based on the results of our model.

Our model also measured the long-run effects through the coefficients of the Error Correction Model (ECM) i.e.ECM_{t-1}. This model is essential to detect the presence of long-run cointegration. The presence of a long-run adjustment in ECM is indicated by a negative sign of the coefficient and it is also statistically significant. The study by Banerjee et al. (1998) confirmed the existence of a long-run relationship, which was shown by the negative and highly significant coefficient of the ECM.

According to Narayan and Narayan (2006),the ECM measures the speed of adjustment to restore equilibrium in the dynamic model. In other words, this model is essential to measure the rate of adjustment from short-run disequilibrium towards the long-run equilibrium. If there is any factor that brings the relationship out of thelong-run equilibrium, the ECM will help to restore the condition. The negative signcoefficient indicates that disequilibrium will converge towards thelong-run equilibrium. From the result, ECT_{t-1} is a negative coefficient and is statistically significant at the 1% level. The magnitude of ECT_{t-1} is –0.2378. It shows that the speed of convergence to the equilibrium is 23.78 percent. In the short-run, economic growth will be adjusted by 23.78 percent of the previous year's deviation from the equilibrium. This implies that it will take approximately 4 years before converging back to the equilibrium path.

This study has also conducted diagnostic and stability tests. The diagnostic tests were the serial correlation, functional form, normality distribution and heteroscedasticity. The diagnostic tests were performed based on the ARDL estimations. Based on the results in Table 5, the study concluded that there was no serial correlation, no functional form misspecification, no heteroscedasticity and the residuals were normally distributed for the model.

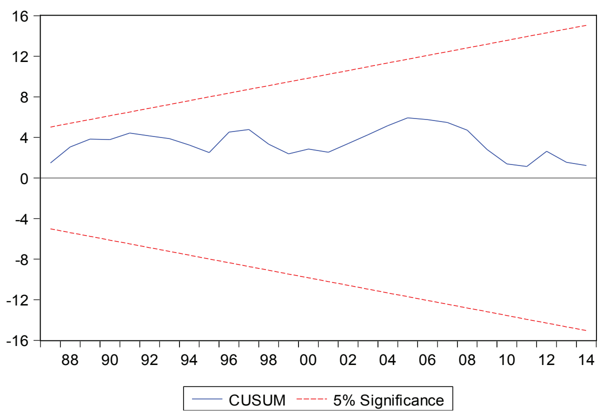
TABLE 5. Diagnostic Tests (LM)

Serial Correlation	0.1021	[0.8557]
Functional Form	0.0329	[0.8575]
Normal Distribution	3.6152	[0.1640]
Heteroscedasticity	0.6737	[0.6797]
CUSUM		Stable
CUSUM Square		Stable

Note: Parenthesis […] shows the probability of the diagnostic test

As for the stability tests, the CUSUM and CUSUM Square were used to test the stability of the model. Based on Figure 1, the CUSUM and CUSUM Square graphs indicate that both were within the critical bounds. If the plot of the CUSUM or CUSUM Square sample path move

Plot of the Cumulative Sum of Recursive Residuals (CUSUM)



Plot of the Cumulative Sum of Square of Recursive Residuals (CUSUM Square)

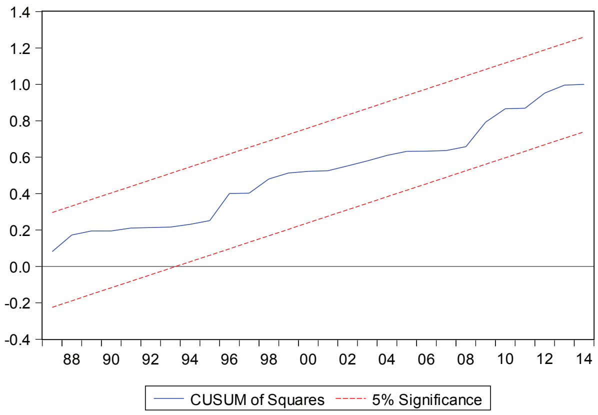


FIGURE 2. CUSUM and CUSUMSQ

outside the critical region (at the 5% significance level), then the null hypothesis of stability is rejected. Since both graphs of the sample paths were within the critical region, this implied that the ECM was stable. Thus, this showed that the long-run form of the long-run estimate was stable. The coefficients of regression can be beneficial in the policy decision-making process.

CONCLUSION

This study utilised the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests to check for the stationarity of all of the variables in the model. The results revealed that all of the variables were integrated of order zero, I(0) and integrated of order one, I(1) and there was no I(2) variable in the model. Therefore, it was appropriate for this study to investigate the relationship of electricity consumption and other determinants with economic growth by using the ARDL bounds testing approach.

The results from the ARDL bounds test found a long-run cointegration relationship in the model being tested. For the long-run estimation, this study found that the LEC and LFDI were positively related to real GDP and both were statistically significant. However,for LK, there was a positive relationship but it had a statistically insignificant value which indicated that there was no long-run relationship with real GDP. The ECM term (ECT_{t-1}) appeared to be negative and significant in the ARDL estimations. The coefficient indicated that the speed of adjustment back to the long-run equilibrium value was statistically significant.

The diagnostic tests showed that the model was free from any problem in which the residuals were shown to be normally distributed and there was no evidence of serial correlation, heteroscedasticity, and functional form misspecification. The stability tests of CUSUM and CUSUM Square were also passed where they were shown to be within the critical region.

Therefore, it can be concluded that electricity consumption and FDI have a significant impact on economic growth in Malaysia. The other determinant variable i.e. real capital was shown to be positively and significantly related to economic growth in the short-run only.

Policy implications and recommendations can be made through the results obtained from this study. The results give important information to policy makers and to government agencies. The overall impact of electricity consumption and economic growth is positive. A change in energy policy will give an impact on the economic output or production in Malaysia. The main sources of electricity generation are liquid fuel and coal to fulfil the energy demand. Since Malaysia's petroleum stocks are depleting, Malaysia should embrace the idea of using alternative energy sources in the future. Moving forward, we can follow the developed countries that focus on using green and clean energy as examples to follow. We should also improve our current energy production and encourage exploration of more renewable energy sources. To do so, the government should provide incentives to encourage research and development (R&D) in the renewable energy.

NOTES

https://data.worldbank.org/

REFERENCES

Adom, P. K. 2011. Electricity consumption-economic growth nexus: The Ghanian case. *International journal of energy economics and policy* 1(1): 18–31.

Akarca, a. T., & Long, T. V. I. 1980. Relationship between energy and GNP: a reexamination. *Journal of Energy and Development*, *5*(2), 326–331. https://doi.org/10.2307/24806899

Alfaro, L., Chanda, A., Ozcan, S. K., & Sayek, S. 2010. Does foreign direct investment promote growth? Exploring the role of financial markets on linkages. *Journal of Development Economics 91*: 242–256.

Aliyu, A. J., & Ismail, N. W. 2015. Foreign direct investment and pollution haven: Does energy consumption matter in African countries? *International Journal of Economics and Management*, *9*(SpecialIssue), 21–39.

Akarca, a. T., & Long, T. V. I. 1980. Relationship between energy and GNP: a reexamination. *Journal of Energy and Development 5*(2): 326–331. https://doi.org/10.2307/24806899

Ang, J. B. 2008. Economic development, pollutant emissions and energy consumption in Malaysia. *Journal of Policy Modeling 30*(2): 271–278. https://doi.org/10.1016/j.jpolmod.2007.04.010

Anhal, R. 2013. Causality between GDP, Energy and Coal Consumption in India, 1970-2011: A Non-parametric Bootstrap Approach. *International Journal of Energy Economics and Policy 3*(4): 434–446.

Azlina, A. A. 2012. Energy Consumption and Economic Development in Malaysia: A Multivariate Cointegration Analysis. *Procedia - Social and Behavioral Sciences 65*(ICIBSoS): 674–681. https://doi.org/10.1016/j.sbspro.2012.11.183

Banerjee, A., Dolado, J., & Mestre, R. 1998. Error-Correction Mechanism Tests For Cointegration In A Single-Equation Framework Wadham College and Institute of Economics and Statistics, University of Oxford, Universidad Carlos III de Madrid and Research Department, Bank of Spain First version rece. *Journal of Time Series Analysis 19*(1995): 1–17.

Bartleet, M., & Gounder, R. 2010. Energy consumption and economic growth in New Zealand: Results of trivariate and multivariate models. *Energy Policy 38*(7): 3508–3517. https://doi.org/10.1016/j.enpol.2010.02.025

Belke, A., Dobnik, F., & Dreger, C. 2011. Energy consumption and economic growth: New insights into the cointegration relationship. *Energy Economics 33*(5): 782–789. https://doi.org/10.1016/j.eneco.2011.02.005

Belloumi, M. 2009. Energy consumption and GDP in Tunisia: Cointegration and causality analysis. *Energy Policy 37*(7): 2745–2753. https://doi.org/10.1016/j.enpol.2009.03.027

Chandran, V. G. R., Sharma, S., & Madhavan, K. 2010. Electricity consumption-growth nexus: The case of Malaysia. *Energy Policy 38*(1): 606–612. https://doi.org/10.1016/j.enpol.2009.10.013

Chang, S. C. 2014. Effects of financial developments and income on energy consumption. *International Review of Economics and Finance 35*: 28–44. https://doi.org/10.1016/j.iref.2014.08.011

Cheng, A. C. S. 1995. The UK stock market and economic factors: a new approach. *Journal of Business Finance & Accounting*, *22*(January) 129–142. Retrieved from http://onlinelibrary.wiley.com/doi/10.1111/j.1468-5957.1995.tb00675.x/abstract

Cheng, B. S., & Lai, T. W. 1997. An investigation of co-integration and causality between energy consumption and economic activity in Taiwan. *Energy Economics 19*(4): 435–444. https://doi.org/10.1016/S0140-9883(97)01023–2

Dogan, E. 2014. Energy Consumption and Economic Growth: Evidence from Low-Income Countries in Sub-Saharan Africa. *International Journal of Energy Economics and Policy 4*(2): 154–162. Retrieved from http://www.econjournals.com/index.php/ijeep/article/view/665%5Cnhttp://www.econjournals.com/index.php/ijeep/article/download/665/418

Eddrief-Cherfi, S., & Kourbali, B. 2012. Energy consumption and economic growth in Algeria: cointegration and causality analysis. *International Journal of Energy Economics and Policy 2*(4): 238–249.

Faisal, Tursoy, T., Resatoglu, N. G., Asafu-Adjaye, J., Asafu-Adjaye, J., Zhang, X. P., … Bhattasali, D. 2016. Energy consumption and economic growth in Vietnam. *Energy Policy 30*(2): 1506–1514. https://doi.org/10.1017/CBO9781107415324.004

Foon Tang, C. 2009. Electricity consumption, income, foreign direct investment, and population in Malaysia. *Journal of Economic Studies 36*(4): 371–382. https://doi.org/10.1108/01443580910973583

Ghatak, S., & Siddiki, J. U. 2001. The use of the ARDL approach in estimating virtual exchange rates in India. *Journal of Applied Statistics 28*(5): 573–583. https://doi.org/10.1080/02664760120047906

Hamdi, H., Sbia, R., & Shahbaz, M. 2014. The nexus between electricity consumption and economic growth in Bahrain. *Economic Modelling 38*: 227–237. https://doi.org/10.1016/j.econmod.2013.12.012

Harris, R., & Sollis, R. 2003. *Applied Time Series Modelling and Forecasting*. Wiley, West Sussex.

Hussain Ali Bekhet & NorSalwati bt Othman. 2011. Causality analysis among electricity consumption, consumer expenditure, gross domestic product (GDP) and foreign direct investment (FDI): Case study of Malaysia. *Journal of Economics and International Finance 3*(4): 228–235. Retrieved from http://www.academicjournals.org/JEIF

Islam, F., Shahbaz, M., Ahmed, A. U., & Alam, M. M. (2013). Financial development and energy consumption nexus in Malaysia: A multivariate time series analysis. *Economic Modelling 30*(1): 435–441. https://doi.org/10.1016/j.econmod.2012.09.033

Islam, F., Shahbaz, M., Alam, M. M. M., Ahmed, A. U., & Alam, M. M. M. 2013. Financial development and energy consumption nexus in Malaysia: A multivariate time series analysis. *Economic Modelling 30*(28403): 29. https://doi.org/10.1016/j.econmod.2012.09.033

Johansen, S., & Juselius, K. 1990. Maximum Likelihood Estimation and Inference on Cointegration — With Applications To the Demand for Money. *Oxford Bulletin of Economics and Statistics 52*(2): 169–210. https://doi.org/10.1111/j.1468-0084.1990.mp52002003.x

Kazemi, M., & Azman-Saini, W. N. W. 2017. Foreign direct investment, economic freedom and democracy. *International Journal of Economics and Management 11*(1):1–15.

Kraft, J., & Kraft, A. 1978. On the relationship between energy and GNP. *The journal of energy and development 3*(2): 401-403.

Lean, H. H., & Smyth, R. 2010. Multivariate Granger causality between electricity generation, exports, prices and GDP in Malaysia. *Energy 35*(9): 3640–3648. https://doi.org/10.1016/j.energy.2010.05.008

Laurenceson, J., & Chai, J. 2003. *Financial reforms and Economic development in China*. University of Queensland, Australia: Edward Elgar

Mahadevan, R., & Asafu-Adjaye, J. 2007. Energy consumption, economic growth and prices: A reassessment using panel VECM for developed and developing countries. *Energy Policy 35*(4): 2481–2490. https://doi.org/10.1016/j.enpol.2006.08.019

Marques, A. C., Fuinhas, J. A., & Menegaki, A. N. 2014. Interactions between electricity generation sources and economic activity in Greece: A VECM approach. *Applied Energy 132*: 34–46. https://doi.org/10.1016/j.apenergy.2014.06.073

Tsani, S. Z. 2010. Energy consumption and economic growth: A causality analysis for Greece. *Energy Economics 32*(3): 582–590. https://doi.org/10.1016/j.eneco.2009.09.007

Zhang, X. P., & Cheng, X. M. 2009. Energy consumption, carbon emissions, and economic growth in China. *Ecological Economics 68*(10): 2706–2712. https://doi.org/10.1016/j.ecolecon.2009.05.011