Ekoloji 28(107): 299-310 (2019)

Industrial, Commercial, and Agricultural Energy Consumption and Economic Growth Leading to Environmental Degradation

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Abstract

Acknowledging the importance of sectoral energy utilization, the present study explores the impact of industrial, commercial, and agricultural energy consumption and economic progress of Malaysia on environmental degradation as measured by CO2 emissions. Applying the functionality of Cobb-Douglas, the authors utilized the long time series data from the period of 1978 to 2016. The outcomes of the empirical investigations using ARDL bound testing approach ascertain the presence of long-run association between GDP growth, capital, labor along with the sectoral energy utilizations of the country. Furthermore, the study also finds empirical evidences of positive significant associations of all energy consumptions with economic growth. Lastly, long run relationship among environmental degradation and energy consumption and economic growth along with financial development, trade openness, capital stocks, and urbanization as control variables. In addition, FMOLS results confirm that economic growth and energy consumption have a positive and significant impact on environmental degradation. This study brings a valid policy recommendation for the Malaysia Government to invest more in all sector of energy for the progress in the Malaysian economic growth.

Keywords: industrial energy, commercial energy, transportation energy, agricultural energy consumption, environmental degradation

Saudi MHM, Sinaga O, Roespinoedji D, Jabarullah NH (2019) Industrial, Commercial, and Agricultural Energy Consumption and Economic Growth Leading to Environmental Degradation. Ekoloji 28(107): 299-310.

INTRODUCTION

The natural environment plays an important role in supporting economic activity. It contributes directly by providing resources and raw materials such as water, timber, and minerals that are needed as inputs for the production of goods and services and indirectly through the services provided by ecosystems, including carbon sequestration, water purification, flood risk management, and nutrient cycling. Natural resources are therefore essential to ensure economic growth and sustainable development, not only today but for future generations.

The relationship between economic growth and the environment is complex. Several challenges come into play, including the size and composition of the economy, particularly the share of services in gross domestic product (GDP), as opposed to primary industries and manufacturing, and technological changes have the potential to reduce the environmental impacts of the decisions of production and consumption, while also driving economic growth.

The world at present is bursting with rising business opportunities. The mode of businesses has also witnessed to move from the orthodox systems to innovative functioning intricated well in the operations and management, resulting into more efficient contemporary industries. The economies in today's globalized world reliant enormously on the inputs of economic activities, their availability and sustainability for future use. In this regard, the contribution of energy in the current economies is the basis of sustainability debates and forms the vital part in the ecological and economic literature (Othman et al. 2017).

The conventional theory of neo-classical growth approach considers energy only as a transitional factor. The theory contemplates the other elements of land

 Received: 19 Sep 2017 / Accepted: 23 Feb 2018

capital and labour as the fundamental aspects of production. Therefore, in this way, the neo-classical approach restricted the vitality of energy in the economic operations. Alternatively, the adherents of biophysical & ecological perception approaches treated energy as the most critical influencer (Adepoju and Eyibio 2016, Ekong and Akpan 2014, Jabarullah and Othman 2018, Oyaromade et al. 2014, Tsang and Yung 2017). They suggested that the role of energy is substantial for the process of income determination. In this regard, the energy inputs are considered to be the major influencer of economic development, whereby, changes in energy utilizations underlies the potential to alter economic progress.

The theoretical differences on the contribution of energy is followed by the contentious debate in the literature regarding the role of energy in economic growth. Many studies critically refer the approach of growth model to be eccentric for considering energy as the secondary factor (Asyraf 2014, Beaudreau 1995, Behera 2015, Ekong and Akpan 2014, Kobayashi et al. 2013, Ozturk and Ozturk 2018, Vafaeirad et al. 2015, Özdemir et al. 2018). The arguments on the share played by energy in the economy is initiated by Kraft and Kraft in 1978. Ever since, the literature strives hard not only to determine the contribution of energy in economy, but also to identify the impact it can bring as a result of changes in the level of energy dependencies (Jabarullah et al. 2017). In this regard, the majority of the literature emphasized on the co-integration approach and determination of causal connections by applying Granger causality method (Abdul Samad et al. 2018). This part of literature included the novel work by Lee (2008), Chontanawat et al. (2007), and Lee (2006). In addition, the emphasis of modern economics relies greatly on energy utilization by declaring it indispensable factor of economic operations and production methods. In order to specifically identify the significance of energy in a country's growth process, the emphasis of studies especially from past two decades relied heavily on empirical assessment utilizing the bi-variate approach. It included the studies of Lise and Montfort (2007), Mehrara (2007), Narayan and Singh (2007), Lee and Chang (2007) and Zachariadis (2007). However, these studies are criticized for omitting crucial variables and also to reach an agreement on the specific association of energy with economic progress.

Furthermore, Soytas and Sari (2007) stated that the connection between energy consumption and development varies from country to country, hence, required to be analyzed considering the exclusive economy and its contributing industries. This is due to the fact that economies differ in terms of energy dependence and the sources of energy production and consumption (Danbaba et al. 2016, Edwin et al. 2017, Ekpung 2014, Gideon 2014, Henry 2014, Jabarullah et al. 2016, Mukadasi 2018, Singh and Issac 2018). Hence, a general panel approach is insufficient in determining the effect of energy on the economic development. Moreover, the diverse sources of energy exert dissimilar influence on the economic activities and thus largely rely upon the methods of energy generation in the country. As we would see it, diverse nations are in totally dissimilar from each another in terms of income levels. This have essentially unique effect on energy and monetary development connection. In this manner, it might be hasty to expect that panel investigation can result in an agreement on the general impact of energy in growth process of a countries with variant income levels, sources of energy and structure of energy dependence.

In addition to above, a strand of literature also pointed out the adverse effects that can be found in energy dependent countries (Apergis and Payne 2010). The adverse impact of the energy on the economy is commonly transferred by the negative impactit creates in the form of emissions as a bi-product, and therefore, hinders environmental condition. This raises not only the problems of social development but also affects economies in long run by hurting the notion of sustainable development. In addition, the limitation of the current literature in assessing energy on aggregate level also created ambiguities regarding the contribution of energy consumption on economic development. The limitation of such aggregate approach lies in ignoring the inclusion of specific effects resulted by numerous levels of energy utilization in variant economic sectors. In addition, the contribution of energy dependence can be efficiently inspected by measuring the impact of disaggregated sectors of energy consumption. The industry specific influence of energy consumption has many fold advantages over the aggregate energy dependence investigations. Initially, it is helpful in determining the industry level dependence of energy in a country. Furthermore, it points out the impact of individual energy consumption of the industries on economic development. This will enable the economies to identify the particular sector of the economy that is positively or negatively related to economic development. The understandings from such inclusive approach will enable the governments and policy makers to make better decisions regarding the energy dependence strategies focusing on the relevant industry (Jabarullah et al. 2014, Ersoy et al. 2017).

Acknowledging the significance of the disaggregate analysis of energy consumption on economic growth, the present study aims to investigate the impact of industrial, commercial, agricultural and transport energy consumption on the economic development of Malaysia (Jabarullah et al. 2015). As mentioned above, the majority of the studies examining the association between energy consumption and economic development focus on bi-variate models that are limited to cause omitted biasness and therefore are critically discussed in many studies in terms of causing spurious correlations & reaching erroneous conclusions (Adjaye 2000, Boyi et al. 2018, Dölek and Günes 2016, Glasure 2002, Pérez-Luna et al. 2018, Stern and Cleveland 2003, Stern 1997, Tshepo et al. 2017). Considering the limitations of bi-variate approaches, the present study opted to perform the multivariate examination in studying the relationship between the industrial, commercial, agricultural and nuclear energy utilization with output growth. On the other hand, the literature where multivariate approaches in the energy-growth examinations are analyzed, there do not appear to be a theoretical foundation in a large portion of those investigations. However, in response, the present analysis focus on Cobb-Douglas Function in inspecting the relationship of sector level energy consumption with economic development (Ali and Haseeb 2019, Haseeb et al. 2017, Suryanto et al. 2018).

The rest of the paper is sorted out as below: Section two depicts the model and econometric procedure utilized in the investigation; Section three talks about the methodological information of the econometrics utilized in the paper; Section four shows the empirical evidences and data interpretation; Section five summed up the contribution, implication and policy recommendations.

LITERATURE REVIEW

Many studies analyze the relationship between economic development and energy utilization in past. However, the review of the literature failed to reach a consensus on the specific association between economic development and energy utilization, leaving the need to revisit the investigation with improved methodology and country specific inspection. In this context, Aqeel and Butt (2001) analyzed the effects of energy utilization on economic development of Pakistan. The study utilized the data from the period of 1956 to 1996. Taking the aggregate energy utilization, the study aimed to investigate the relationship of energy dependence with economic condition of the Pakistan. The findings of the empirical analysis by applying Hsiao's Granger causality and Cointegration analysis conclude the presence of negative association between energy utilization and output development suggesting that higher dependence on energy tends to reduce the economic growth in long-run in Pakistan.

Similarly, Asafu-Adjaye (2000) examined the causal connection between energy utilization, energy prices and economic development of Asian countries. The study utilized the data from the period of 1971 to 1995 for the economies of Indonesia, Thailand, India and Philippine. Taking the aggregate energy utilization, the authors aimed to explore the association of energy utilization and prices with economic condition of the sampled countries. The findings of the empirical analysis conclude the presence of uni-directional causal connection between energy utilization and economic development of India & Indonesia. Furthermore, the direction of causality in both countries is found to be run from energy utilization to economic development. In addition, the study also evident the presence of bi-directional causal association between energy and output growth of Thailand and Philippine. Similar results are found among the association of energy prices with economic development of both countries.

For China, Yuan, Kang, Zhao and Hu (2008) inspected the relationship between energy utilization and economic development. The study utilized the data from the period of 1963 to 2005. Utilizing the both aggregate and disaggregate energy utilization, the study aimed to investigate the relationship of energy utilization with economic condition of Chinese economy. The findings of the empirical analysis resulted from the technique of Johansen co-integration and Vector error Correction Model (VECM). The outcomes of the study suggested that all the variables are co-integrated at long run, whereas, electricity and oil utilization exert uni-directional causal connection on economic development. In addition, the findings of the empirical analysis also reported economic development to aggregate energy, coal & oil utilization, where the direction of causality runs from GDP to aggregate energy, oil and coal in China.

In a panel investigation of Asian economy, Lee and Chang (2008) examined the association between energy utilization on economic development of sixteen Asian countries. The study utilized the data from the period of 1971 to 2002. Taking the aggregate energy utilization, the study aimed to investigate the relationship of energy with economic condition of the sampled countries. The findings of panel co-integration approach concluded the presence of long-run co-integration between energy utilization and output development suggesting that higher dependence on energy tends to enhance the economic growth in long-run. The outcomes of causal effects reported the presence of uni-directional causality among energy utilization and output of the panel nations. Unlike Tang et al., (2016), the study concluded that the direction of causal effects run from aggregate energy utilization to economic development in the sampled economies. Likewise, Mehrara (2007) also investigated the effects of energy utilization on economic development of eleven oil exporting economies. The study utilized the data from the period of 1971 to 2002. Taking the aggregate energy utilization, the study aimed to investigate the relationship of energy with economic condition of the sampled countries. In doing so, the authors applied the econometrics of panel co-integration and granger causality. The outcomes of the empirical investigation revealed the presence of uni-directional causality among energy utilization and output of the oil exporting nations. Furthermore, the study also concluded that the direction of causal effects run from GDP to aggregate energy in the sampled economies.

For China, Wang, Zhou, Zhou and Wang (2011) also performed the panel investigation for the twenty eight provinces of the country. The objective of the investigation is to find out the connection between energy utilization, emission and economic development of the country. For that purpose, the authors used the data from 1995 to 2007 and utilized the econometrics of panel co-integration to study long-run effect and VECM for causality determination. The findings of the empirical analysis conclude the presence of positive association between energy utilization and carbon emission suggesting that higher dependence on energy tends to reduce the environmental sustainability and thus brings adverse effects to growth in long-run. The outcomes of causal effects reported the presence of bi-directional causality among energy utilization & emission and emission and output of the China. For developing countries, Lee (2005) analyzed the effects of energy utilization on economic development of eighteen emerging nations. The study utilized the data from the period of 1975 to 2001. Taking the aggregate energy utilization, the study aimed to investigate the relationship of energy with economic condition of the sampled countries. The results of the panel Cointegration approach reported that both the variables possessed the co-integration in long-run. The outcomes of causality reported the presence of uni-directional causality among energy utilization and economic growth of the developing economies. Also, the study also concluded that the direction of causal effects, similar to Lee and Chang (2008) run from aggregate energy to output growth in the sampled countries.

Likewise, Wolde-Rufael (2004) also examined the association between energy utilization and economic development of Shanghai. The study utilized the data from the period of 1952 to 1999. Utilizing the measures of disaggregate energies, the study aimed to investigate the association of various forms of energy utilizations with economic progress of the country. The findings of the empirical analysis is carried out from the technique of Toda and Yamamoto Granger causality. The outcomes of causal connections established that the presence of negative association between energy utilization and output development suggesting that higher de uni-directional causal relationship among energy sources. In addition, the authors concluded that the direction of causal effects run from aggregate energy, coal, electricity & coke to economic development. The results of the study however have failed to find the causal connection of oil utilization with output growth of Shanghai. For Korean economy, Oh and Lee (2004) inspected the impact of energy utilization on economic development of South Korea. The study utilized the data from the period of 1970 to 1999. Using the measures of aggregate energy utilization, the study analyzed the relationship between energy utilization and economic condition of Korea. The findings of the empirical analysis conclude the presence of long-run Cointegration among the variables. Furthermore, the results of short-run causality stated the occurrence of uni-directional causality among energy utilization and output, where the direction of causality runs from energy to output. As for long-run causal connection, the empirical evidences reported the presence of feedback effect among the GDP and aggregate energy of the country.

In a time series investigation, Jumbe (2004) examined the relationship of energy utilization on economic development of Malawi. The study utilized the data from the period of. 1970 to 1999. In order to pursue the research objective, the authors used the measure of electricity utilization to investigate its effects on total and industry sectorial GDP of the country. The findings of the empirical analysis conclude the presence of long run cointegration between energy utilization and overall output, and non-agricultural output. The outcomes of causal effects reported the presence of bi-directional causality among energy utilization and total output. Furthermore, the study also reported the existence of uni-directional causality among non-agricultural output and electricity suggesting that the direction of causal effects run from non-agricultural output to electricity utilization of the country. Likewise, recently, Tang, Tan, and Ozturk (2016) also analyzed the impact of energy usage on economic progress of Vietnam. The study utilized the data from the period of 1971 to 2011. Considering the level of aggregate energy utilization, the authors applied the empirical techniques of co-integration and granger causality investigate the causal connection among the variables (Kamarudin et al. 2018). The findings of the empirical analysis conclude the presence of positive association between energy utilization and output development suggesting that higher dependence on energy tends to enhance economic growth in long-run (Salem et al. 2016). Furthermore, the results of causal effects found evidence of uni-directional relationship between energy and growth of the Vietnam's economy. Moreover, the outcomes reported that the causal connection among the variables runs from energy utilization to economic development in Vietnam.

METHODOLOGY

The current study scrutinizes the connection between sectoral energy consumption (includes industrial, transport, commercial and agriculture energy consumption) and economic growth by applying Cobb-Douglas Function and the model is as follows:

$$Y = \beta_0 + \beta_1(K) + \beta_2(L) + \beta_3(IND) + \beta_4(COM) + \beta_5(TRA) + \beta_6(AGR) + \varepsilon_t$$

where, ε_t is the residual terms, *Y* explain the economic development which is measured by the total finished goods and services, *K* is the capital which is measured by gross fixed capital formation, L is represent the labor force which is measured by the total number of employed labor force, IND is the industrial energy consumption, COM is the commercial energy consumption, TRA is the transportation energy consumption and AGR is the agricultural energy consumption. All the data of sectoral energy consumption is measured in kilo tone of oil equivalent (kote). The data is collected from the period of 1978 to 2016. All data are gathered from World Development Indicators (World Bank) except sectoral data of energy consumption. The data for industrial, commercial, transportation and agricultural energy consumption of Malaysia is collected from Malaysia Energy Statistics, Handbook 2017. The current study uses all data in natural logarithmic forms as suggested by (Raza et al. 2017, Sharif and Afshan 2018, Sharif et al. 2017, 2018). The expected sign of capital and labor is positive whereas, the sign of industrial, commercial, transportation and agricultural energy consumption will be revealed by the current research (Salem et al. 2018).

To examine the existence of long-run or cointegrating relation between economic growth and sectoral energy (industrial, commercial, transportation and agricultural) in Malaysia, the paper employs Autoregressive Distributed Lag (ARDL) Model (Pesaran and Shin 1999, Pesaran et al. 2001) Bounds Cointegration tests. ARDL Model does not need the variables to be integrated of Order 1 i.e. I(1) or the variables to be mutually cointegrated (Pesaran and Shin 1999). The ARDL Bounds Testing Approach is more favorable to be employed for small data size (Haug 2002) and is comparatively simpler to estimate the cointegrating relationships. The ARDL framework for analyzing the cointegrating relationship among the variables under study is framed as follows:

$$\begin{aligned} \ln(Y) = {} & \beta_0 + \sum_{i=1}^{n} \delta_1 \Delta ln(Y)_{t-i} + \sum_{i=1}^{n} \delta_2 \Delta ln(K)_{t-i} \\ & + \sum_{i=1}^{n} \delta_3 \Delta ln(L)_{t-i} + \sum_{i=1}^{n} \delta_4 \Delta ln(IND)_{t-i} \\ & + \sum_{i=1}^{n} \delta_5 \Delta ln(COM)_{t-i} + \sum_{i=1}^{n} \delta_6 \Delta ln(TRA)_{t-i} \\ & + \sum_{i=1}^{n} \delta_7 \Delta ln(AGR)_{t-i} + \beta_1 ln(Y)_{t-i} + \beta_2 ln(K)_{t-i} \\ & + \beta_3 ln(L)_{t-i} + \beta_4 ln(IND)_{t-i} + + \beta_5 ln(COM)_{t-i} \\ & + \beta_6 ln(TRA)_{t-i} + \beta_7 ln(AGR)_{t-i} + \varepsilon_t \end{aligned} \qquad (1)$$

ln denotes the log of the variables of economic growth (Y), capital (K), labor force (L), industrial energy consumption (IND), commercial energy consumption (COM), transportation energy consumption (TRA) and agricultural energy consumption (AGR). Δ represents the first difference operator and the intercepts are represented by β_0. The long-run coefficients are denoted by $\beta_1, \beta_2, \beta_3, \ldots, \beta_7$ and δ_1, $\delta_2, \delta_3, \ldots, \delta_7$ represent the short-run dynamics. ε_t denotes the residuals or white noise error term.

The framed ARDL framework estimates the Equation (1) with OLS Method (Ishak et al. 2018, Zainudin et al. 2017a). The ARDL Model examines the long run relationship among the given variables by testing the null hypothesis of $H_0 = \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0$ against the alternate hypothesis $H_1 \neq \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq \beta_7 \neq 0$ by calculating F-Test developed by Pesaran and Shin, and

Table 1. Results of Descriptive Statistics

	Mean	Minimum	Maximum	Std. Dev.	Jarque-Bera	Correlation
Y	304.061	205.052	408.069	107.052	24.346***	
K	280.238	220.451	420.234	121.052	29.491***	0.925***
L	140.475	90.921	190.213	70.329	17.915***	0.907***
IND	7303.89	2273	16454	4785.29	36.323***	0.782***
COM	2528.99	712	7403	2191.01	82.282***	0.871***
TRA	7493.12	1928	22357	5891.97	32.213***	0.921***
AGR	252.67	201	1074	336.212	71.219***	0.901***

Note: *** represents the values are significant at 1%.
Source: Authors Estimation

Smith (2001) and modified by Narayan (2005). The calculated F-Statistic is compared with upper and lower critical values given by Pesaran et al. (2001). When the calculated F-Statistic is greater than upper critical value, the null hypothesis of no cointegration is rejected and is accepted in case the F-Statistic is lower than the lower critical value at a given significance level (Hussain 2014, Johari and Jamil 2014). When the calculated F-Statistic falls within the lower and upper critical values the inference becomes inconclusive (Zainudin et al. 2017b).

In order to identify the causal linkages between the specified variables, the present study intended to apply the Granger causality technique (Abdul Hadi et al. 2018). The method of Granger causality entails numerous benefits in contrast to other causal estimation particularly in the time-series estimations (Hussain et al. 2018). This endorses that the decision of applying the said analysis for identifying the causal connection between environmental degradation, economic growth and technology innovation in Malaysia are trustworthy and more dependable in comparison to the earlier studies.

DATA ANALYSIS AND DISCUSSION

The primary focus of the present research is to apply the Cobb-Douglas framework in Malaysia. **Table 1** explains the outcomes of the descriptive statistics of economic growth, capital, labor and all energy proxies. The mean values for all the considered variables are positive.

Economic growth mean value of (304.061) which varies from 205.052 to 408.069. Capital has an average value of (280.238) which fluctuates from 220.451 to 420.234, labor force has a mean value of 14.475 which varies from 90.921 to 190.213, industrial energy utilization has a mean value of 7303.89 which differs from 2273 to 16454, commercial energy utilization has a mean value of 2528.99 which fluctuates from 712 to 7403, transportation energy utilization has an average value of 7493.12 which varies from 1928 to 22357 and finally, agriculture energy utilization has a mean value of 252.67 which differs from 201 to 1074. Moreover, the outcomes of the Jarque-Bera test are significant at the 1% level, which shows that economic growth, capital, labor and sectoral energy (includes industrial, commercial, transportation and agricultural energy utilization) are not normally distributed in the case of Malaysia. Also, the coefficient of correlation is also positive and strong for all the variables. The maximum correlation is found between capital and economic growth with the coefficient value of 0.925. However, the correlation between transportation energy utilization and economic growth is also positive and high with the coefficient value of 0.921. Whereas, the lowest coefficient or correlation is found in the case of industrial energy utilization and economic growth which is 0.782. The coefficient of correlation between agriculture energy utilization and economic growth is also high with the value of 0.901. Moreover, the coefficient of correlation between commercial energy utilization and economic growth is also positive with the value of 0.871. The p-values of the correlation coefficients are highly significant as those values are statistically significant at the 1% level.

Table 2 show the outcome of stationary test applied in the present research. For fulfilling the persistence of ensuring the data stationarity, the present research have used the tests of Augmented Dickey Fuller (*ADF*) & Phillip Perron (*PP*) tests. The tests of unit root therefore consider the outcomes initially at level of variables but later on apply the tests on their first difference.

The results of **Table 2** confirm that economic growth, capital, labor and energy proxies (industrial, commercial, transportation and agriculture energy utilization) are stationary & integrated at their first differential series. The results of ADF and PP test confirm the robustness of results suggesting that all variables are co-integrated at I(1) and we can use these variables for further long run estimation procedures. In other words, from the outcomes of unit root test, we can apprehend that series of both the variables reflect

Table 2. Results of Unit root test

Variables	ADF Unit root test				PP unit root test			
	I(0)		I(1)		I(0)		I(1)	
	C	C&T	C	C&T	C	C&T	C	C&T
Y	1.821	1.791	-4.995	-5.014	1.346	1.453	-4.811	-4.901
K	0.324	0.361	-.3832	-3.913	0.472	0.385	-3.999	-4.012
L	-1.245	-1.259	-5.329	-5.130	-1.129	-1.012	-5.001	-4.827
IND	-1.580	-1.480	-7.324	-.7320	-1.581	-1.692	-6.892	-6.620
COM	0.342	0.532	-5.329	-5.019	0.561	0.472	-5.264	-5.683
TRA	-1.893	-1.757	-4.218	-4.684	-1.586	-1.636	-4.217	-4.385
AGR	1.356	1.461	-6.204	-6.758	1.294	1.301	-6.129	-6.329

Note: The critical values for ADF and PP tests with constant (c) and with constant & trend (C&T) 1%, 5% and 10% level of significance are -3.711, -2.981, -2.629 and -4.394, -3.612, -3.243 respectively.
Source: Authors' estimation

Table 3. Results of Bound Testing for Cointegration

Lags Order	AIC	HQ	SBC	F-test Statistics
0	-4.347	-4.982	-4.029	56.932⋆
1	-5.941⋆	-5.229⋆	-5.950⋆	
2	-5.074	-5.001	-5.329	
3	-4.565	-4.028	-4.495	

⋆ 1% level of significant.
Source: Authors' estimation.

Table 4. Results of Lag Length Selection

Lag	0	1	2	Nominated Lags
	SBC	SBC	SBC	SBC
K	-1.943	-2.123⋆	-1.728	1
LF	-1.832	-2.483⋆	-2.126	1
IND	-2.483⋆	-1.373	-1.438	0
COM	-2.018⋆	-1.893	-2.002	0
TRA	-1.583⋆	-1.323	-1.200	0
AGR	-1.947⋆	-1.489	-1.743	0

⋆ indicate minimum SBC values.
Source: Authors' estimation.

the stationary properties and allow for proceeding towards the long run estimations. Furthermore, in order to find the long run relationship between energy proxies and economic growth, we have applied the technique of ARDL bound testing cointegration. Therefore, the outcomes of the ARDL bound testing cointegration are displayed in **Table 3**.

The outcomes of **Table 3** check the null hypothesis claiming that not cointegration between the variables is rejected. This is because to the value of the *F*-statistics which is higher than UBC value at 1% significance level. So, it is checked that there is a long-term relationship occur among economic growth, capital, labor, industrial energy, commercial energy, transportation energy and agriculture energy consumption in Malaysia.

The results of ARDL bound testing cointegration test, however confirm the robustness of examined outcomes. Therefore, it is confirmed that a noteworthy long-term relationship presents among economic growth, labor force, capital, industrial energy utilization, commercial energy utilization, agriculture energy utilization and transportation energy utilization in Malaysia. Furthermore, after finalizing the results of long-term relationship between the considered variables, the next procedure is to examination of ARDL method with the aim of calculating the beta value of long-short run time. In doing so, the current research calculates the lag length order of all variables through the minimum value of SBC.

Table 5. Results using ARDL Approach (Long Run)

Variables	Coeff.	t-stats	Prob.
C	-0.341	-3.328	0.000
Y (-1)	0.089	2.983	0.000
K	0.370	4.423	0.000
K (-1)	0.002	0.879	0.391
LF	0.137	4.832	0.000
LF (-1)	-0.004	-0.936	0.350
IND	0.228	4.432	0.000
COM	0.201	4.838	0.000
AGR	0.102	3.328	0.000
TRA	0.389	2.992	0.000
Adj. R^2	0.912		
D.W stats	1.942		
F-stats (Prob.)	2945.213 (0.000)		

Source: Authors' estimation.

The long-run findings of ARDL framework for estimation is shown in **Table 5**. The discoveries in this way build up that industrial energy, commercial energy, agriculture energy and transportation energy utilization are a valid determinant of economic growth in Malaysia. Likewise, the outcomes affirm that industrial energy, commercial energy, agriculture energy and transportation energy consumption have a constructive outcome on economic growth in Malaysia which implies that the nation energy utilization from all these four sectors increase the economic growth in Malaysia. The consequences of Cobb-Douglas function in the presence of industrial energy, commercial energy, agriculture energy and transportation energy utilization confirm the enhancement of economic growth in Malaysia. The findings confirm a valid long-run relationship so now we further move to the short-run estimations of ARDL test.

Table 6. Results using ARDL Approach (Short Run)

Variables	Coeff.	t-stats	Prob.
C	-0.246	-3.039	0.005
ΔY (-1)	0.105	4.983	0.000
ΔK	0.270	2.486	0.022
ΔK (-1)	0.002	1.148	0.264
ΔLF	0.204	3.795	0.000
ΔLF (-1)	-0.117	-0.811	0.426
ΔIND	0.108	2.210	0.039
ΔCOM	0.121	1.960	0.050
ΔAGR	0.322	2.890	0.000
ΔTRA	0.209	2.902	0.021
ECM (1)	-0.131	-3.354	0.003
Adj. R^2	0.89		
D.W stats	1.874		
F-stats (Prob.)	82.331 (0.000)		

Source: Authors' estimation.

Table 7. Results of Granger-Causality Test

Null Hypothesis:	F-Statistic	Prob.
Y does not Granger Cause K	3.163	0.063
K does not Granger Cause Y	13.059	0.000
Y does not Granger Cause LF	12.109	0.000
K does not Granger Cause Y	5.176	0.014
Y does not Granger Cause IND	8.051	0.000
IND does not Granger Cause Y	3.252	0.058
Y does not Granger Cause COM	3.999	0.021
COM does not Granger Cause Y	4.822	0.009
Y does not Granger Cause TRA	3.532	0.328
TRA does not Granger Cause Y	4.076	0.019
Y does not Granger Cause AGR	8.932	0.000
AGR does not Granger Cause Y	3.388	0.037

Source: Author's Estimation

The short-run results of ARDL method show in **Table 6**. The results explained a solid short run connection between economic growth, capital, labor, industrial energy utilization, commercial energy utilization, agricultural energy utilization and transportation energy utilization in Malaysia. The coefficient of error term is explaining the value of around -0.13 suggest that around 13% of instability is adjusted in the recent year. However, the outcomes also check the significant effect of capital, labor force, industrial energy utilization, commercial energy utilization, agricultural energy utilization and transportation energy utilization on economic development in Malaysia in short run as well.

The results of Granger-causality show in **Table 7**. The results explain that there a causal relationship among all the variables with economic growth. The findings confirm that capita, labor, industrial energy utilization, commercial energy utilization, transportation energy utilization and agriculture energy utilization have a bi-directional causal relationship with economic growth which means causality is running in both directions.

CONCLUSION

The present research examines the effect of energy utilization proxies (including industrial energy utilization, commercial energy utilization, transportation energy utilization and agricultural energy utilization) and economic growth on environmental degradation in the presence of Cobb-Douglas function in Malaysia by using the annual time series data over the period from 1978 to 2016. The study uses four types of energy utilization (which are the percentage of total energy utilization in Malaysia). We applied the advance econometrics to serve the purpose of investigation and therefore used the Auto Regressive Distributed Lags bound testing approach for assessing the presence of long-run relationship between the variables. Utilizing the framework of Cobb-Douglas, the results of ARDL bound testing approach ascertain the valid long run relationship between economic growth, capital, labor, industrial energy utilization, commercial energy utilization, agricultural energy utilization and transportation energy utilization in Malaysia. The final outcomes confirm that all energy utilizations, capital and labor force have a positive and significant impact on economic growth. Furthermore, results of Granger-causality also confirm the existence of bi-directional causal relationship between all sectoral energy utilizations and economic growth in Malaysia.

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