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Article

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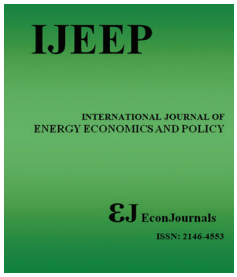

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The Impact of Hydropower Energy on the Environmental Kuznets Curve in Malaysia

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ABSTRACT

The present research examines the effect of hydropower energy consumption in testing the Environmental Kuznets Curve in Malaysia by using the annual time series data over the period from 1978 to 2016. The present research applied the advance econometrics to serve the purpose of investigation and therefore used the auto regressive distributed lag (ARDL) bound testing approach for assessing the presence of long-run relationship between the variables. The results of ARDL bound testing approach confirm the valid long run relationship between hydropower energy consumption and economic growth with carbon dioxide emission in Malaysia. The final outcomes confirm that hydropower energy consumption and square of economic growth have significant and negative impact on carbon dioxide emission whereas, the economic growth have a significant and positive impact on carbon dioxide emission. Furthermore, results also confirm the existence of inverted U-Shape curve in Malaysia. The results provide a solid evidence for the policymakers to focus on hydropower energy consumption while formulating the policy for the reduction of environmental degradation in Malaysia.

Keywords: Hydropower, Green Energy, Renewable Energy, Sustainable Development
JEL Classifications: O11, Q20, Q23,

1. INTRODUCTION

Energy is considered as indispensable in today's World. It led to generate the power that is resulted from the deployment of physical or chemical resources in order to pull together the essentials of electricity, heat and fuel that are crucial for human and economic development. In modern economies, energy is considered as the significant catalyst of economic activities (Apergis and Payne, 2015). It is utilized as the major input in industries, commercial, transportation and agriculture sectors. Though, the vitality of energy is not solely limited to businesses. One of the integral facets of energy is also the household energy. The countries have witnessed that societal development and communal orders are changed from subsistence to the current advancement from the utilization of energy (Othman et al., 2017). It is now considered as the important part of human development as it leads to bring improvements in peoples' quality of life. Furthermore, the utilization of biomass as an origin of energy is the significant feature of conventional agriculture systems. The image of present-day industrialized society is based on the utilization of non-renewable energy sources including coal, oil and natural gas. These elements have turned out to be critical component of all communal developments in present civilization.

However, the literatures have also found that excessive energy dependence can also bring adverse effects on environment and thus hinders the process of sustainable development (Jebli and Youssef, 2015; Dogan and Seker, 2016; Sharif and Afshan, 2016; Sharif et al., 2017; Sharif et al., 2018). Furthermore, the theoretical foundations in this regard present many studies that capture the effects of numerous variables that hinder environmental sustainability (Kobayashi et al., 2013; Henry, 2014; Danbaba et al., 2016; Jabarullah et al., 2016; Zomorrodi and Zhou, 2017). Among them, the framework of environment Kuznets curve

(EKC) presents the significant theoretical foundation by analysing the effects of critical factors on the environment (Jabarullah et al., 2017). The conventional hypothesis of EKC inspects the contribution of economic development in influencing environment deterioration. The common assertion, in this regard, stated that economic growth tends to improve environmental degradation in early stages, however in long-term, it is seen to bring negative effects on the environment (Jabarullah et al., 2015). The model of EKC is being famous for enhancing the understanding of economic activities and their association with the environment. Keeping in mind the rising emphasis of countries, governments and businesses on the domain of ecological development, the literature has also witnessed the rising trend in the studies of environmental sustainability (Ekpung, 2014; Chidoko, 2014; Zomorrodi and Zhou, 2016; Qazi et al., 2017; Wireko-Manu and Amamoo, 2017; Sharif et al., 2018; Fernández et al., 2018; Sharif and Afshan, 2018).

In this context, many scholars have offered the academia their valuable contribution utilizing the framework of EKC (Kasman and Duman, 2015). In addition to the conventional examination of studying the relationship between economic development and environment, the literature has been found to extend the structure of EKC to include the inspection of elements that are considered auxiliary to economic activities and exert major influence on economic process. Hence, with the growing interest in the field of environmental degradation, numerous researches aimed to analyse the authenticity of EKC approach by including the critical factors of economic development along with the conventional economic growth (Jabarullah et al., 2014). In this regard, Cole (2004) investigated the role of trade in causing environmental degradation. Among the assessments of monetary features of the economy, the framework of EKC have also been validated by adding the critical variables of inequality by Torras and Boyce (1998) and financial growth by Javid and Sharif (2016). Similarly, from the aspect of societal expansions, Martínez-Zarzoso and Maruotti (2011) studied EKC with the inclusion of urbanization, Ehrhardt-Martinez et al. (2002) by investigating the effects of de-forestation and Ozturk et al. (2016) by adding the influence of tourism in the EKC approach.

Furthermore, the recent studies have started to evaluate the insertion of energy consumption (Jebli et al., 2016; Dogan and Seker, 2016) followed by the rising emphasis of economic, financial and ecological experts in identifying the contribution of numerous forms of energy consumption in influencing environmental degradation. This includes the studies of Dong et al. (2018) and Zoundi (2017) that emphasized on examining the role of renewable and non-renewable sources of energy in explaining environmental deterioration. Nevertheless, the existing studies of energy consumption are more focused in examining the overall effects of energy and failed to analyse the specific contribution of energy generation as they tend to affect the environment differently.

Energy consumption and production is basically categorized in two famous forms. They include the sources of energy that are either fall under the sphere of renewables or non-renewables. In other words, energy can be generated from coal, natural gas, nuclear energy, oil etc. to be utilized in economic and societal activities (Halicioglu, 2009). Alternatively, it can be generated from the utilization of eco-friendly sources, also renowned as renewable sources, like solar, wind, biofuels etc. (Apergis and Payne, 2014; Gideon, 2014; Adebambo et al., 2014; Luong et al., 2017; Zhang, 2017; Al-Fatlawi, 2018). However, among the numerous sources of energy generation, one of the most critical sources of energy is hydro power. The sphere of energy derived from hydro power is excessively debatable for being environmentally friendly or not. In this regard, one viewpoint categorized it as renewable for attaining from hydro sources and therefore considers it eco-friendly. On the other hand, the adherents of alternate view suggest that energy generation from hydro-power put numerous burdens on the environment and therefore should not be categorized as renewable energy. Nonetheless, the debate on the relationship of energy generation from hydro-power with environment sustainability form an interesting setting to be analysed.

Therefore, the objective of the present study is to investigate the theoretical and empirical foundations of environmental Kuznets curve by the inclusion of hydropower energy consumption. As the role of hydro-power in effecting environment is debatable to exert positive or negative influence of the ecological sustainability, hence the outcomes of the present study, tend to enhance the existing body of knowledge in the domain of hydro-power energy consumption of Malaysia. To the best of our awareness, the current study is pioneer in analysing the relationship of hydropower energy consumption under the sphere of EKC approach in Malaysia and thus strengthens the theoretical contribution of EKC framework. Furthermore, the exclusivity of the current investigation is further extended in offering methodological contribution by investigating the association of hydro-power consumption with environmental deterioration through applying the rigorous empirical technique of auto-regressive distributed lags (ARDL) bound testing in examining EKC model. The understandings derived from such unique and advance methods can deliver improved insights in the integrated domains of economic and ecological commissions. Moreover, the expected findings of the current study can enable the policy makers to understand the magnitude of hydro-power generation on environmental deterioration and thus help them to articulate proper policies, guidelines and strategies in curtailing the adverse consequences of hydro-power energy consumption on Malaysian environmental sustainability.

The remaining of the empirical investigation is outlines as follows: Section two presents the review of current studies related to energy consumption and environmental deterioration; section three depicts the methods of empirical analysis utilized in the present examination; section four interpret the findings of empirical examination and finally section five concludes the research outcomes and provide implication and future recommendations.

2. LITERATURE REVIEW

As mentioned earlier, many studies analysed the validity of EKC by examining the association of economic growth and environmental degradation. In recent studies, there exists an upsurge in the inclusion of energy consumptions in the investigations of EKC model. Among them, Nordin and Kun (2018) examines the validity of EKC with the

inclusion of energy consumption in a panel of twenty-four countries. The variables utilized in the study include gross domestic product, energy consumption and carbon emissions. The study utilized the data from the period of 1973 to 2013. The empirical investigation of the study is carried out by applying the 2nd generation panel unit root, along with the co-integration test to investigate long run associations. In order to examine short run association, the authors applied VAR granger causality approach. Distributing the panel into oil importing and oil exporting economies, the statistical findings of the investigation conclude that there is a significant short run impact of GDP and energy consumption on carbon emissions of oil importing economies. In addition, the outcomes revealed that in long-run, there exist feedback effects among the variables for oil exporting economies (Abidin et al., 2015; Azam et al., 2016; Haseeb, 2018; Haseeb and Azam, 2015).

In China, Wang et al. (2011) inspected the connection of energy consumption with environmental degradation in twenty-eight provinces of the country. In doing so, the study utilized the data from the period of 1995 to 2007. Moreover, the study applied the empirical analysis of panel co-integration to study long-run effect and VECM to assess causal connections of GDP and energy consumption with carbon emissions. The results of the analysis concluded the presence of long-run co-integration among the variables. Furthermore, the study similar to Nordin and Kun (2018) supported the existence of bi-directional causal connections among carbon emissions and economic growth and energy consumption among the provinces of China.

In the time series investigation, Ang (2007) analysed the contribution of energy consumption and economic growth in the environmental degradation in France. The study used the data from the period of 1960 to 2000 to investigate the validity of EKC framework. Applying the same methodology as Wang et al. (2011), the findings of the study established that economic growth have causal association with energy consumption and environmental degradation. In addition, the findings of the study also supported the existence of uni-directional causal association of energy consumption with output, where the direction of causality run from energy utilization to growth (Abidin et al., 2014; Azam et al., 2016; Haseeb and Azam, 2015; Haseeb et al., 2014).

For China, Zhang and Cheng (2009) also examined the association between energy consumption, carbon-di-oxide emission and output growth. In doing so, the study utilized the data from the period of 1960 to 2007. In order to examine the causal connection among the variables, the authors applied the Granger causality test. The results of the analysis concluded the presence of causal connections among carbon emissions, economic growth and energy consumption among the provinces of China. In particular, the study concluded that energy consumption granger causes the environmental degradation in long run. Furthermore, the result also establishes the uni-directional causal connections among output and energy consumption suggesting that the direction of causal effects among the variables run from output to energy consumption in China.

In another Panel investigation, Arouri et al. (2012) analysed the role of energy consumption and gross domestic product in curtailing environmental degradation. The authors measured environmental degradation by using the proxy of emissions resulted from carbon-di-oxide in the environment. For the purpose of validating environmental Kuznets curve, the study utilized the data from the period of 1981 to 2005 in a panel of twelve MENA countries. The results of the study revealed the weak validation of EKC curve considering output growth and carbon emissions. As for, energy consumption, the findings of the study established the presence of significant long-run association of energy utilization with environmental degradation in MENA countries. Furthermore, the results submitted the positive influence of energy consumption on carbon emissions suggesting that greater utilization of energy tends to enhance environmental deterioration in the sampled economies (Abidin and Haseeb, 2015; Haseeb et al., 2014; Haseeb et al., 2014; Haseeb et al., 2017; Israhadi, 2018).

In a comparative examination of the India and China, Jayanthakumaran et al. (2012) inspected the connection of income, energy utilization and trade with carbon emissions. The study used the data from the period of 1971 to 2007 and applied the econometrics of ARDL bound testing to investigate dependencies of studied variables on environmental degradation. The findings of the study established that emissions of carbon in China is influenced by energy utilization and income, however, the study failed to find such connection among the variables for India. Similarly, Ang (2008) analysed the association between energy utilization, output and pollution in Malaysia. The study measure pollution in terms of emission in the country resulted from carbon-di-oxide. In order to assess the long run connections among the variables, the study utilized the data from the period of 1971 to 1999. The outcomes of the empirical investigation revealed the significant relationship of pollution and energy consumption with economic development of Malaysia. Furthermore, the findings of causal examinations supported the existence of uni-directional association of energy consumption with output growth and similarly pollution with Malaysian economic development. The direction of causality in both cases is found to be run from output development to energy utilization in the sampled time period.

In another time series investigation Soytas and Sari (2007) examine the relationship of energy utilization and output with environmental degradation in Turkey. In order to measure degradation, the authors utilized the proxy of carbon-di-oxide emissions. For the purpose of examining the long-term impact of the energy and growth on carbon emissions, the study used the data from the period of 1960 to 2000. By applying the techniques of VAR and Granger causality, the results of the study reported the significant long-run association between energy consumption and carbon emissions. Moreover, the results of granger causality confirm the uni-directional causal connection between energy usage and emissions. However, the direction of causality, unlike Ang (2007) suggest that causal effects run from carbon emission to energy consumption in Turkey.

In examining the link between carbon emission and energy consumption, Soytas et al. (2007) investigated the relation between energy utilization, income and carbon-di-oxide emissions. The study used the data from the period of 1960 to 2004 to capture the validity of

EKC curve in United States. The empirical investigation is carried out by applying the causal approaches of VDM and Granger causality. The results of the causal analysis reported that energy consumption have significant causal connection with carbon emissions. However, the study failed to find the presence of causal effects running from income to carbon emissions in USA. Similarly, Dogan and Turkekul (2016) also inspected the validity of environmental Kuznets curve in United States with the inclusion of energy utilization, financial progress, urban advancements and trade from the period of 1960 to 2010. The empirical evidences from the techniques of ARDL bound testing and Granger causality established the significant long-run association of energy utilization, urban development and trade with carbon emissions. In addition, the outcomes revealed that energy usage and urban development enhanced the levels of carbon emissions but trade openness declined it. On the other hand, the study failed to validate the existence of EKC and the significance of financial development for the case of USA. Furthermore, the results of causal investigation reported the existence of feedback relationship between emissions and output, emissions and energy usage and emissions and urban developments. However, the study concluded the absence of causal relationship among emissions and trade and emissions and financial development of USA.

3. METHODOLOGY

The current study scrutinizes the connection between carbon dioxide emission, economic growth, and hydropower energy consumption by applying environmental Kuznets Curve model and the model is as follows:

$$CE=\beta_0+\beta_1(Y)+\beta_2(Y^2)+\beta_3(\text{RENE})+\beta_4(\text{HYD})+\varepsilon_t$$

Where, ε_t is the residual terms, Y explain the economic development which is measured by the total finished goods and services, Y^2 is the square of economic development, *HYD* explains the hydropower energy consumption which is explained by portion of total energy consumption. However, *CE* represents the carbon dioxide emission which is measured in metric kilo tons. The data is collected from the period of 1978 to 2016. All data are gathered from World Development Indicators (World Bank) except hydropower energy consumption. The data for hydropower energy consumption is collected from Malaysia Energy Statistics, Handbook 2017. The current study uses all data in natural logarithmic forms as suggested by (Sharif et al., 2018; Sharif et al., 2017). The expected sign of economic growth is negative whereas, the sign of hydropower energy consumption will be revealed by the current research.

3.1. Stationarity Approaches

First, we check the stationary properties for long-run relationship of focused time series data, the present research applies Augmented Dickey Fuller (ADF) and Phillip Perron (PP) unit root tests. We examine the data initially on level and then on first differential series.

3.2. Long Run Co-integration Analysis

Secondly, we examine the role of hydropower energy consumption in testing Environmental Kuznets Curve in Malaysia, we apply the ARDL technique of long run connection which was introduced by Pesaran et al. (2001, 2000), Pesaran and Shin (1999), Pesaran and Pesaran (1997) is used with the help of unobstructed VECM to investigate the long-term relationship between hydropower energy consumption, economic development and carbon dioxide emission. The ARDL approach has various features on previous conventional long-run relationship analyses (like J.J Cointegration and others) (Hussain et al., 2018). The ARDL approach can be helpful nevertheless of whether focus series are purely *I(0)*, *I(1)* or equally co-integrated (Pesaran and Shin, 1999). The ARDL framework is proposed for above examination is as follow:

$$\Delta CE = \varphi_0 + \varphi_1 \sum_{i=1}^{p} \text{CE}_{t-1} + \varphi_2 \sum_{i=1}^{p} \text{Y}_{t-1} + \varphi_3 \sum_{i=1}^{p} \text{Y}^{2}_{t-1} + \varphi_4 \sum_{i=1}^{p} \text{HYD}_{t-1} + \varphi_5 \sum_{i=1}^{p} \text{ENC}_{t-1} + \gamma_1 \text{CE}_{t-1} + \gamma_2 \text{Y}_{t-1} + \gamma_3 Y^2_{t-1} + \gamma_4 HYD_{t-1} + \mu_t$$

Where, φ_0 is constant term and μ_t is white noise error term, the error correction boundary is denoted by the sign of summation whereas the other measure of the equation relates to long-term connection. The Schwarz Bayesian criteria (SBC) is used to investigate the optimal lag length choice for every variable. In ARDL approach, firstly, the present research measures the *F*-statistics significance by utilizing the appropriate ARDL models. Secondly, the Wald (*F*-stats) test is utilized to examine the long-term connection among the variables. If long-term bonding between carbon dioxide emission, economic growth and hydropower energy consumption are recognized, after that the current research identify the long-run coefficient calculations by utilizing below framework.

$$\text{CE}_t = \zeta_0 + \zeta_1 \sum_{i=1}^{p} \text{CE}_{t-1} + \zeta_2 \sum_{i=1}^{p} \text{Y}_{t-1} + \zeta_3 \sum_{i=1}^{p} \text{Y}^2_{t-1} + \zeta_4 \sum_{i=1}^{p} \text{HYD}_{t-1i} + \mu_t$$

If the long-run connection between carbon dioxide emission, economic growth and hydropower energy consumption are found after that the current study calculates the short run beta value by utilizing below framework:

$$\text{CE}_t = \delta_0 + \delta_1 \sum_{i=1}^{p} \text{CE}_{t-1} + \delta_2 \sum_{i=1}^{p} \text{Y}_{t-1} + \delta_3 \sum_{i=1}^{p} \text{Y}^2_{t-1} + \delta_4 \sum_{i=1}^{p} \text{HYD}_{t-1} \text{nECT}_{t-1} + \mu_t$$

Table 1: Results of descriptive statistics

Variables	Mean	Minimum	Maximum	SD	Jarque-Bera	Correlation
CE	247.467	87.641	301.181	1.213	18.741***	-
Y	34.061	25.052	48.069	0.052	24.346***	0.925***
HYD	14.475	9.921	19.213	0.329	17.915***	−0.907***

***Represents the values are significant at 1%. Source: Authors estimation. SD: Standard deviation

The error correction model (ECM) explain the adjustment speed of residual terms which shows the long-run equilibrium because of short-term shock. The *n* is the value of error correction term in the framework that explain the adjustment speed in the present framework.

4. DATA ANALYSIS AND DISCUSSION

The primary focus of the present research is to test the Environmental Kuznets Curve in Malaysia. Table 1 explains the outcomes of the descriptive statistics of carbon dioxide emission, economic growth and hydropower energy consumption. The mean values for all the considered variables are positive.

Carbon dioxide emission a mean value of (247.467) which varies from 87.641 to 301.181. Economic growth has an average value of (34.061) which fluctuates from 25.052 to 48.069 and finally, hydropower energy consumption has a mean value of (14.475) which differs from 9.921 to 19.213. Moreover, the outcomes of the Jarque-Bera test are significant at the 1% level, which shows that carbon dioxide emission, hydropower energy consumption and economic growth are not normally distributed in the case of Malaysia. Also, the coefficient of correlation is also positive and strong for economic growth whereas a negative correlation coefficient is found between hydropower energy consumption and environmental degradation in Malaysia. The maximum correlation is found between carbon dioxide emission and economic growth with the coefficient value of 0.925. However, the correlation between carbon emission and hydropower energy consumption is negative and high with the coefficient value of −0.907. 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 ADF and 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 findings of Table 2 recognized that both carbon emission and hydropower energy consumption with economic growth are stationary and integrated at their first differential series. The results of both tests 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 the stationary properties and allow for proceeding towards the long run estimations. Furthermore, in order to find the long run relationship between environmental degradation and hydropower energy consumption, the authors have applied the technique of ARDL bound testing cointegration. Therefore, the outcomes of the ARDL bound testing cointegration are displayed in Table 3.

The results of Table 4 confirm the null hypothesis claiming that not cointegration between the variables is rejected. This is due to the coefficient of the *F*-stats is larger than UBC coefficient at 1% significance level. So, it is confirmed that there is a long-term connection occur among carbon dioxide emission, economic growth and hydropower energy consumption in Malaysia.

The results of ARDL bound testing cointegration test, therefore, establish the robustness of achieved results. It is indicated that a significant long-term association presents among carbon dioxide emission, non-renewable energy, economic growth, technology innovation and renewable energy consumption in Malaysia. Moreover, after confirming the evidence of long-term connection between the considered variables, the further step of the examination is to apply the ARDL method with the aim of finding the beta value of long-short run time. In doing so, the present study measures the lag length order of all the considered variables through the minimum value of SBC.

The long run results of ARDL method of estimation is displayed in Table 5. The findings therefore establish that economic growth and hydropower energy consumption are valid determinants of carbon emission in Malaysia. Also, the results confirm that economic growth have a positive effect of carbon emission in Malaysia which means that the country economic progression increase the level of carbon dioxide emission in Malaysia. Also, it can be argued that hydropower energy consumption and square of economic growth play a significant role to reduce the carbon dioxide emission in Malaysia which means that invert U-Shape EKC curve exists in Malaysia. The results of EKC curve and hydropower energy consumption highlights that in the starting the growth of economy increases the carbon emission in the country but after getting the substantial growth it helps to reduce the environmental degradation in the case of Malaysia.

The short-run outcomes of ARDL method displayed in Table 6. The findings showed a valid short run relationship between economic growth, hydropower energy consumption and carbon dioxide emission in Malaysia. The coefficient of error term is showing the value of around −0.23 suggest that around 23% of instability is adjusted in the present year. Moreover, the outcomes also check the significant effect of economic growth and hydropower energy consumption on carbon dioxide emission in Malaysia in short run as well.

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
CE	1.328	1.412	−4.124	−4.219	1.215	1.229	−4.124	−0.3983
Y	−0.335	−0.413	−4.813	−4.721	−0.574	−0.533	−4.293	−4.021
HYD	2.472	2.139	−6.167	−6.365	2.174	1.938	−6.019	−5.988

The critical values for ADF and PP tests with constant © and with constant and trend (C&T) 1%, 5% and 10% level of significance are −3.711, −2.981, 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	−5.583	−5.232	−5.839	38.321*
1	−6.231*	−6.168*	−6.237*	
2	−6.024	−5.921	−5.983	
3	−5.565	−5.102	−5.495	

*1% level of significant. Source: Authors' estimation. SBC: Schwarz Bayesian criteria

Table 4: Results of lag length selection

Lag	0	1	2	Nominated lags
	SBC	SBC	SBC	SBC
Y	−1.238	−1.823*	−1.217	1
HYD	−1.942	−2.483*	−2.019	1

*Indicate minimum SBC values. Source: Authors' estimation. SBC: Schwarz Bayesian criteria

Table 5: Results using ARDL approach (Long run)

Variables	Coeff.	t-stats	Prob.
C	0.185	2.957	0.000
CE (−1)	0.024	4.325	0.000
Y	0.477	5.782	0.000
Y (−1)	0.002	3.217	0.000
Y^2	−0.194	−4.325	0.000
Y^2 (−1)	−0.024	−0.936	0.350
HYD	−0.219	−4.679	0.000
HYD (−1)	−0.103	−5.452	0.000
Adj. R^2		0.783	
D.W stats		2.019	
F-stats (Prob.)		1049.213 (0.000)	

Source: Authors' estimation. ARDL: Auto regressive distributed lag

Table 6: Results using ARDL approach (short run)

Variables	Coeff.	t-stats	Prob.
C	0.012	3.512	0.000
ΔCE (−1)	0.051	2.845	0.000
ΔY	0.129	3.947	0.000
ΔY (−1)	0.004	1.375	0.170
ΔY^2	−0.195	−5.627	0.000
ΔY^2 (−1)	−0.029	1.598	0.112
ΔHYD	0.251	4.679	0.000
ΔHYD (−1)	0.104	3.287	0.000
ECM (1)	−0.231	−4.313	0.000
Adj. R^2		0.759	
D.W stats		1.936	
F-stats (Prob.)		871.546 (0.000)	

Source: Authors' estimation. ARDL: Auto regressive distributed lag

5. CONCLUSION

The present research examines the effect of hydropower energy consumption in testing the Environmental Kuznets Curve in Malaysia by using the annual time series data over the period from 1978 to 2016. The study uses hydropower energy consumption (% of total energy consumption), economic growth, square of economic and carbon dioxide emission as a proxy of environment and measured in metric kilotons. We applied the advance econometrics to serve the purpose of investigation and therefore used the ARDLs bound testing approach for assessing the presence of long-run relationship between the variables. Utilizing the framework of EKC, the results of ARDL bound testing approach confirm the valid long run relationship between hydropower energy consumption and economic growth with carbon dioxide emission in Malaysia.

The final outcomes confirm that hydropower energy consumption and square of economic growth have significant and negative impact on carbon dioxide emission whereas, the economic growth have a significant and positive impact on carbon dioxide emission. Furthermore, results also confirm the existence of inverted U-Shape curve in Malaysia.

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