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**Article**

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# Dynamic Impact of Energy Consumption, Private Investment and Financial Development on Environmental Pollutions: Evidence from Malaysia

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**ABSTRACT**

This study is aimed at exploring the impact of energy consumption, private investment, financial development and economic growth on carbon dioxide ($CO_2$) emissions in Malaysia employing the autoregressive distributed lags model for the period 1976-2013. The result reveals the presence of long run association connecting the variables and established that private investment and energy consumption impact positively on $CO_2$ emissions in Malaysia. For that reason, the study recommends the implementation of clean technology by private investors is essential in managing $CO_2$ emissions in Malaysia.

**Keywords:** Carbon Dioxide Emissions, Private Investment, Energy Consumption, Autoregressive Distributed Lag, Malaysia
**JEL Classifications:** C53, O16, Q41

## 1. INTRODUCTION

The danger of climate change as a result increase in global warming is becoming a global issue of concern on environmental sustainability in the past two decades. It is considered that increase in carbon dioxide ($CO_2$) emissions level is among the main factor leading to climate instability and global warming (Heidari et al., 2015). Therefore, policy makers are paying more attention on how to reduce the level of $CO_2$ emissions. In addressing this concern, it is important to strategise on how to strike balance between economic variables and climate change, as the relationship between climate change and economic variables cannot be avoided (Grossman and Krueger, 1994). This is attributed to the fact that most economic variables affect the level of $CO_2$ emissions. The incidence of this concern is extreme in many developing nations like Malaysia, where environmental sustainability and economic variables are jointly important.

The government in Malaysia has targeted reducing the intensity of $CO_2$ emissions by about 40% (Ministry of Natural Resources and Environment, 2011) and at the same time aimed at achieving high-income country by the year 2020 (National Economic Advisory Council, 2009). Therefore, it is important to find out if the goals of achieving growth together with environmental sustainability can be jointly accomplished. Many studies have attempted to examine $CO_2$ emissions together with other economic variables. Taking the instance of the United States (US), Jorgenson and Wilcoxen (1990) noticed that the slow growth of economy goes along with the introduction of environmental policies, where environmental policies tend to affect the performance of the economy. Yet, the subsidies on petroleum products contribute to speeding up economic growth in Malaysia as it has boost productivity (Abdullah et al., 2009). Besides, the economic power of Malaysia has moved from agriculture to industrial sector from 1970 to 1980 (Hasan, 2007). Accordingly, the consumption of energy has increased significantly because industrial sector required more energy as compared to the agricultural sector. Presently, Malaysian economic development is shifting to the service sector, which required more energy. For that, the goal of reducing $CO_2$ emissions by 40% might not be feasible, except the economy will considerably shift to technology that has low $CO_2$ emissions.

Arising from the above scenario, this study intended to explore the effect of energy consumption, private investment, aggregate output and financial development on environmental pollutions in Malaysia during the period 1976-2013 utilizing the autoregressive distributed lags (ARDL) bounds test. The finding of this study therefore, is anticipated to offer new possibilities for policy makers

to strategize a more extensive environmental policy in Malaysia. The paper will be presented in the subsequent approach: Section 2 offers the review of related literature, while method of analysis is contained in Section 3. The estimated result is provided in Section 4 and finally, the last section accommodates the policy implications and offers the conclusion of the study.

## 2. LITERATURE REVIEW

The association connecting economic growth and energy consumption with $CO_2$ emissions can be categorized toward three groups of literature. The first group of research, for example, Halkos (2003), Fodha and Zaghdoud (2010) and, Liu et al. (2016) paid attention on $CO_2$ emissions-growth nexus which attempt at validating the Environmental Kuznets curve (EKC) hypothesis. The second group of investigation, for instance, Stern and Cleveland (2004), Ozturk (2010), Ozturk et al. (2010), Quedraogo (2013), Al-Mulali and Sab (2012), Danmaraya and Hassan (2016a) Solarin and Ozturk (2016) and Sama and Tah (2016). Bayat et al. (2017) and Hassan et al. (2018) concentrated on energy-growth nexus where issues of energy consumption are related to economic performance. The third category of research such as: Soytas and Sari (2009), Govindaraju and Tang (2013), Salahuddin and Gow (2014), Al Mamun et al. (2014), Ben Jebli et al., 2015 and Tang and Tan (2015) attempted at merging the $CO_2$ emissions-growth nexus with energy-growth relationship. In this case, the dynamic link among economic growth, energy consumption and environmental pollutions are analyzed.

The link connecting aggregate output with energy starts with the initial work of Kraft and Kraft (1978) and since then, a lot of researches have tried in attempting to investigate energy-growth relationship with contradicting findings. While some studies, such as Apergis and Payne (2010), Odhiambo (2014), Iyke (2015), Danmaraya and Hassan (2016b) and Tang et al. (2016) argued in support of causal link moving from energy consumption to aggregate output. Other studies, for example, Ouedraogo (2013), Stern and Enflo (2013) and Ahmed and Azam (2016) argued that aggregate output causes the consumption of energy. Also, for the third category, bidirectional causality was discovered among aggregate output and energy utilization. In this case, there exist a feedback relationship among energy and aggregate output (Ziramba, 2009, Rahman et al., 2015; Solarin and Ozturk, 2016). The last categories are of the view that both aggregate output and energy consumption does not cause one another. This is otherwise known as the neutrality group (see for example: Oh and Lee, 2004; Alper and Oguz, 2016).

Taking the instance of causality flowing from energy consumption to aggregate output, Danmaraya and Hassan (2016) used the ARDL bound procedure for Nigeria in investigating manufacturing productivity and electricity consumption and found causal connection from electricity consumption to manufacturing productivity. Similarly, Odhiambo (2014) studied aggregate output and energy consumption for three Sub-Saharan African region within a multivariate framework and established causality flowing from energy consumption to gross domestic product (GDP) in South Afrrica and Kenya Republic. Likewise, Tang et al. (2016) used the neoclassical framework for Vietnam in trying to investigate the link connecting economic performance and the consumption of energy and reveals causality flowing from energy consumption to economic performance. Rafindadi and Ozturk (2016) examined the long-run and short-run effects of financial development, economic growth, export, imports and capital on the Japanese energy predicaments as a result of the foregoing energy crisis in the country. The existence of the feedback relationship between most of the variables was discovered, while, economic growth, exports, imports, and trade openness were found to Granger-cause electricity consumption. The study advocates the adoption of massive but competitive renewable energy system in Japan.

In the second group of findings, Ouedraogo (2013) employed panel data technique in testing economic performance and energy consumption for a panel of 15 ECOWAS nations and found a short-run unidirectional causality flowing from economic performance to energy consumption. Also, Stern and Enflo (2013) found that output causes energy consumption in Swedish using Granger causality approach. In the same way, Ahmed and Azam (2016) studied 119 countries and confirm causality moving from aggregate output to energy consumption in 25 nations.

In the feedback hypothesis group, Ziramba (2009) utilized disaggregated energy data and Toda-Yamamoto technique for South African and maintained a feedback relationship between industrial output and oil consumption. Similarly, Rahman et al. (2015) explored sectoral productivity and energy consumption for Malaysia by using Toda-Yamamoto causality test and suggests bi-directional link among electricity consumption and industrial performance and among coal consumption and aggregate output. In addition, Solarin and Ozturk (2016) explored economic performance and natural gas consumption in OPEC countries and revealed feedback hypothesis in Ecuador.

In the neutrality group of findings, Oh and Lee (2004), suggested neutrality hypothesis for Korea, meaning that there is no causal association among aggregate output and energy consumption. Neutrality hypothesis was supported for some European Countries (EU) including Estonia, Poland, Cyprus, Slovenia and Hungry (Alper and Oguz, 2016). Finally, Solarin and Ozturk (2016) explored economic performance and natural gas consumption in the OPEC and revealed neutrality hypothesis in Angola and Qatar.

Similarly, the association connecting economic growth environmental pollution starts with the original effort of Grossman and Krueger (1991) for North America, which demonstrated that in the initial stage, environmental quality tend to deteriorate as per capita GDP increases, but later improve with further increase in GDP per capita. This brought about the EKC hypothesis that suggests economic performance and environmental pollution have an inverted U-shaped relationship. Since then, many studies concentrated on the EKC hypothesis with diverse conclusions. For instance, Saboori et al. (2012) investigated the EKC hypothesis for Malaysia and established a U-shaped association connecting economic growth with $CO_2$ emissions. Suggesting that $CO_2$

emissions were found decreasing with increase in income. Furthermore, an inverted U-shaped link among aggregate output and environmental pollutions was established in the studies of Halkos (2003) for OECD and non-OECD countries, Jalil and Mahmud (2009) for China, Pao and Tsai (2010) for BRIC countries, Heidari et al. (2015) for Association of South East Asian Nations, Bento and Moutinho (2016) for Italy, Al-Mulali et al., 2016 for Kenya, among others.

Detailing into the inverted U-shaped hypothesis, Halkos (2003) applied the random coefficient and the Generalized Method of Moments (GMM) for 75 OECD and non-OECD countries and failed to reject the EKC hypothesis. This implies that the relationship connecting aggregate output and environmental pollution arising from sulfur was found to have an inverted U-shape relationship. Similarly Pao and Tsai (2010) examined the dynamic association among energy, output and environmental pollutions for BRIC countries and uphold the EKC Hypothesis. Meaning that output and environmental pollution displayed the inverted U-Shape pattern with EKC hypothesis. In similar finding, Bento and Moutinho (2016) used the Autoregressive Distributed Lags (ARDL)- bound technique in analyzing international trade, pollution and aggregate output for Italy and validated the EKC hypothesis for Italy, which indicated that aggregate output decrease pollutions over time.

Yet, some studies such as De Bruyn et al. (1998) and Begum et al. (2015) asserted that the EKC hypothesis cannot hold and hence the EKC is invalid in explaining aggregate output and environmental pollutions. In the study of Begum et al. (2015) for Malaysia, $CO_2$ emissions was found decreasing with increase in economic growth in the initial stage (1970-1980) as $CO_2$ emissions increase in the later period (1980-2009) with increase in economic growth. Also, De Bruyn et al. (1998) reconsider the basis of the EKC hypothesis and argued that over time the inverted U-shape for pollution and income cannot hold for individual country specific for the panel data analyzed. These contradict the EKC hypothesis.

Moreover, other economic variables such as financial development, population growth, trade openness, capital formation and Foreign Direct Investment (FDI) were included in examining energy consumption, aggregate output and $CO_2$ emissions. Yet, it was discovered that private investment was found to be a missing variable in the study of environmental pollutions, aggregate output and energy consumption. Some few studies like Talukdar and Meisner (2001) and Fu et al. (2014) attempt at including private investment in this relation, but still this is not enough to justify the relationship between private investment and $CO_2$ emissions.

## 3. METHOD OF ANALYSIS

### 3.1. Data

This paper is a time series study; therefore it employed annual data for Malaysia between 1976 to 2013 on $CO_2$ emissions, aggregate output, financial development, energy consumption and private investment. The data of this study is obtained from the World Bank database. Table 1 describes the variables employed in this study.

### 3.2. Empirical Model

Following Ang (2007), examining the link of $CO_2$ emissions with aggregate output, private investment, energy usage and financial development is given by Equation (1).

$$CO_2 = f(PI,ENG,FD,GDP) \quad (1)$$

where $CO_2$ represents $CO_2$ emissions, PI denotes private investment, ENG represents energy consumption, FD represents financial development and GDP represents GDP growth. The model is further specified by taking the logarithm of Equation (1) and including the error term, which lead to the specification of Equation (2):

$$\ln CO_2 = \rho_0+\rho_1 \ln PI_t+\rho 2 \ln ENG_t+\rho_2 \ln FD_t+\rho_4 \ln GDP_t \varepsilon_t \quad (2)$$

where ε represents error term as ln represents natural logarithm. Likewise, ρ1,ρ2,ρ3 and $\rho_4$ are the parameters of the dependent variable with respect to the independent variables.

### 3.3. Unit Root Test

Detecting the point of integration on individual variable is regarded as the first conventional process in analyzing time series data. In consideration of the fact that time series data that is non-stationary can result to spurious regression. This reason mandated that all the series, $CO_2$, PI, ENG, FD and GDP are subjected to non-stationarity test by utilizing the Augmented Dickey-Fuller (ADF) (1979) and Phillips and Perron (1988) stationarity tests. Confirming the series to be stationary qualifies the study to assess the presence of cointegration connecting the variables.

### 3.4. Cointegration Test

In testing cointegration, various techniques have been proposed, which includes: The maximum likelihood advanced by Johansen (1988) and Johansen and Juselius (1990), the residual based method offered by Engle and Granger (1987) as well as ARDL method advanced by Pesaran et al. (2001). The ARDL-Bound method is utilised in this study in probing cointegration connecting the variables utilized. This approach is superior to other methods of analysis as the method can be used without regarding whether the series are integrated of order zero I(0) or first order I(1) or even the combination of both as against other techniques such as Johansen which demand the variables to be of the same order of. Likewise, this method accommodates small sample size. These properties have made the ARDL test to be a well-known approach lately. The ARDL ($p,q_1,q_2,q_3,q_4$) model used in this study is given by Equation (3):

$$\Delta \ln CO_{2_t} = \sum_{k=1}^{p} \omega_{1k} \Delta \ln CO_{2_{t-1}} + \sum_{k=1}^{q_1} \omega_{2k} \Delta \ln PI_{t-k} + \sum_{k=1}^{q_2} \omega_{3k} \Delta \ln ENG_{t-k} + \sum_{k=1}^{q_3} \omega_{4k} \Delta \ln FD_{t-k} + \sum_{k=1}^{q_4} \omega_{5k} \Delta \ln GDP_{t-k} + \delta_{11} \ln CO_{2_{t-1}} + \delta_{12} \ln PI_{t-1} + \delta_{13} \ln ENG_{t-1} + \delta_{14} \ln FD_{t-1} + \delta_{15} \ln GDP_{t-1} + \varepsilon_{1t} \quad (3)$$

where ε is the residuals, which is expected to be normally distributed, Δ symbolizes first difference operator and ω represents dynamics of error correction as δ represents long run relationships. Using F-test, cointegration is examined between the variables where the null hypothesis that $H_0$: $\delta_{11}=\delta_{12}=\delta_{13}=\delta_{14}=\delta_{15}=0$ is tested against $H_1$: $\delta_{11}\neq\delta_{12}\neq\delta_{13}\neq\delta_{14}\neq\delta_{15}\neq0$. In deciding cointegration among the variables, $H_0$ will be rejected if the F-statistic value is discovered to be above the upper bound. Contrary to that, if the F-statistic value is discovered less than the lower bound, $H_0$ is fail to be rejected, while the result turn out to be inconclusive if the F-statistic value is found in between the higher and the lower bounds.

### 3.5. The Long Run Estimation

Following the cointegration test, next process is estimation of long run elasticities to enable the study to establish the coefficients of the variable. Equation (4) presents the long run coefficients of the variable employed

$$\ln CO_{2t} = \eta_0 + \sum_{k=1}^{p}\eta_{1k}\ln CO_{2_{t-k}} + \sum_{k=1}^{q_1}\eta_{2k}\ln PI_{t-k} + \sum_{k=1}^{q_2}\eta_{3k}\ln ENG_{t-k} + \sum_{k=1}^{q_3}\eta_{4k}\ln FD_{t-k} + \sum_{k=1}^{q_4}\eta_{5k}\ln GDP_{t-k} + \mu_{it} \quad (4)$$

Where ln stands for the natural log, η denotes long run coefficients as $\mu_{it}$ represents the stochastic error term.

### 3.6. The Short Run Estimation

Having proved the existence of cointegration and the estimated long run elasticities, the study then estimate the short run elasticities to establish the rate of adjustment to unite to the long-run equilibrium (ECM). Equation [5] presents the short run coefficients.

$$\Delta\ln CO_{2t} = \lambda_0 + \sum_{k=1}^{p}\lambda_{1k}\Delta\ln CO_{2_{t-k}} + \sum_{k=1}^{q_1}\lambda_{2k}\Delta\ln PI_{t-k} + \sum_{k=1}^{q_2}\lambda_{3k}\Delta\ln ENG_{t-k} + \sum_{k=1}^{q_3}\lambda_{4k}\Delta\ln FD_{t-k} + \sum_{k=1}^{q_4}\lambda_{5k}\Delta\ln GDP_{t-k} + ECM_{t-1} + \upsilon_{it} \quad (5)$$

where ln stands for the natural log, λ represents the short run coefficients, $\varepsilon_{it}$ represents the white noise error term while $ECM_{t-1}$ represents lag error correction term. The ECM measured the rate of tuning back to long run equilibrium. It is the adjustment mechanism that stabilizes the disequilibrium in the model.

## 4. ESTIMATION OF RESULTS

### 4.1. Unit Root Test

To discover the order of integration I(d) of individual variable and detect the possibility of examining cointegration connecting the variables, this study utilized the PP and ADF unit root tests to find out the stationarity properties of the variables. The unit root test result is demonstrated in Table 2. The result shows that the series were discovered to be non-stationary at level using PP and ADF unit root test. Conversely, after taking the first difference, the series turn back to be stationary. Meaning that all the series happens to be I(1) variables. Hence, the study proceeds with the estimation of cointegration using the ARDL-bound test.

### 4.2. Optimal ARDL Model

The second ARDL process is to select the Optimum ARDL model. The optimal lag included in the model is constructed on Akaike Information Criteria. The optimum ARDL model is given by ARDL (1, 2, 2, 0, 0) presented in Table 3.

### 4.3. Cointegration Test

In the recent time, the ARDL-Bound test has increased popularity and widen acceptance in view of its many advantages as against other techniques of cointegration. In this sub-section, the ARDL model is utilized to establish cointegration between the variables or otherwise. Table 4 presents ARDL-bound test to discover the long-run connection between the variables.

From Table 4, the estimated result of the bound test pointed out that the estimated F-statistic of 4.031 is higher than the upper bound at 5% significance level. Therefore, the study reject null hypothesis, which states that there is no cointegration, is rejected at 5% significance level. This concludes that the variables are moving jointly in the long run, which signifies the presence of a long run association connecting the variables. Establishing long-run connection between the variables gives an opportunity to investigate the long-run and short run coefficients.

**Table 1: Definition of variable and sources of data**

| Variables | Description | Definition | Source |
|---|---|---|---|
| CO2 | DV | CO2 emissions in kilo terms (kt) | WDI |
| PI | IV | Private investment (RM Million) | WDI |
| GDP | IV | G DP growth | WDI |
| FD | IV | Financial development represents domestic credit from financial sector | WDI |
| ENG | IV | Energy consumption (kilogram of oil equivalent) | WDI |

**Table 2: Unit root test**

| Series | ADF | | PP | |
|---|---|---|---|---|
| | Levels | First difference | Levels | First difference |
| ln $CO_2$ | −1.815 | −6. 665* | −1.910 | −6.681* |
| | (0.675) | (0.000) | (0.627) | (0.000) |
| lnENG | −2.587 | −6.533* | −2.587 | −7.141* |
| | (0.287) | (0.000) | (0.287) | (0.000) |
| lnPI | −2.563 | −6.475* | −2.561 | −6.475* |
| | (0.297) | (0.000) | (0.289) | (0.000) |
| lnFD | −2.355 | −5.363* | −2.355 | −5.530* |
| | (0.395) | (0.001) | (0.395) | (0.000) |
| lnGDP | −2.589 | −5.288* | −2.715 | −5.259* |
| | (0.287) | (0.000) | (0.236) | (0.000) |

*Represents statistically significant at 5% level of significance. Figures in parenthesis represent probability. $CO_2$: Carbon dioxide, GDP: Gross domestic product

### 4.4. Long Run Coefficient

Proving the presence of cointegration qualifies this study to examine the elasticities of each of the variable in the long-run. Table 5 demonstrates the long run coefficient of the variable.

Table 5 demonstrates that in the long run, the elasticity of private investment is significant in explaining environmental pollutions at 10% level of significance. Meaning that private investments significantly affect $CO_2$ emissions. The coefficient of 0.12 indicates that one% rise in private investment amount to 0.12% rise in $CO_2$ emissions in Malaysia. Consequently, it can be concluded that private investment in Malaysia pollutes environment. Similarly, the elasticity of energy consumption is significant in explaining environmental pollutions at 5% level of significance. Meaning that the consumption of energy impacts positively on $CO_2$ emissions. For instance a one% increase in the consumption of energy would raise environmental pollutions by 2.14% in Malaysia. The result of energy consumption followed the findings of Ali et al. (2016) for Nigeria, which revealed a positive influence of energy usage on environmental pollutions. Likewise, the result of private investment is related to the study of Fu et al. (2014) for China where domestic investment contributed to $CO_2$ emissions. However, the finding contradict Talukdar and Meisner (2001) for developing countries where increase in private investment lower environmental degredation. On the contrary, financial development and economic growth are proven to be insignificant in explaining $CO_2$ emissions in Malaysia.

### 4.5. Short Run Coefficient

Establishing the long-run connection and the coefficients of the long-run permit us to estimate the short-run elasticities of the variables. Table 6 explains the short-run ECM and the elasticities of the variables.

**Table 3: Optimal ARDL model selection, ARDL (1, 2, 2, 0, 0)**

| Variable | Coefficient | Standard error | *t*-statistic | Prob |
|---|---|---|---|---|
| ln $CO_2$ (-1) | 0.398 | 0.162 | 2.459 | 0.022* |
| lnENG | 1.064 | 0.233 | 4.565 | 0.000* |
| lnENG (-1) | −0.336 | 0.262 | −1.280 | 0.213 |
| lnENG (-2) | 0.563 | 0.243 | 2.314 | 0.030* |
| lnPI | 0.122 | 0.048 | 2.532 | 0.018* |
| lnPI (-1) | 0.037 | 0.053 | 0.696 | 0.493 |
| lnPI (-2) | −0.085 | 0.051 | −1.669 | 0.108 |
| lnFD | −0.010 | 0.067 | −0.156 | 0.877 |
| lnGDP | −0.170 | 0.148 | −1.149 | 0.262 |
| C | −0.563 | 0.265 | −2.124 | 0.044* |

*represents 5% level of significance. ARDL: Autoregressive distributed lags, $CO_2$: Carbon dioxide, GDP: Gross domestic product

**Table 4: ARDL bounds test results**

| Variables | *F*-stat | Lag | Sig. level (%) | Critical values | |
|---|---|---|---|---|---|
| | | | | I (0) | I (1) |
| | 4.031* | 4 | 10 | 2.45 | 3.32 |
| | | | 5 | 2.86 | 4.01 |
| | | | 1 | 3.74 | 5.06 |

*represents 5% significance level. ARDL: Autoregressive distributed lags

Table 6 displays that in the short-run, private investment and energy consumption impact positively on $CO_2$ emissions. The coefficients of 1.06 and 0.12 implied that one% increase in the consumption of energy and private investment would increase environmental pollutions in the short run by 1.06% and 0.12%, respectively. On the contrary, the coefficients of the short run show that aggregate output and financial development does not have any effect on $CO_2$ emissions. The ECM measured the speed of adjustment that convergence to the long-run equilibrium, which is anticipated to be negative and less then 1. The coefficient of −0.60 reveals about 60% rate of adjustment and convergence to the long run equilibrium.

### 4.6. Diagnostic Checking

To ensure the consistency and efficiency of the estimated models, the study conducted diagnostic checking on the models. Table 7 shows the result of serial correlation, normality and heteroscedasticity test. From the table, the null hypothesis of no serial correlation, normality and Heteroscedasticity was failed to be rejected. Hence, it can be established that the model has passed the diagnostic check.

The strength of the model is proved by the cumulative sum of recursive residuals (CUSUM) and CUSUM square. Figures 1 and 2 displayed that the series are inside the critical bound at 5% significance level, which confirmed the model to be stable over time.

## 5. POLICY IMPLICATION AND CONCLUSION

From the policy point of interpretation, policy makers ought provide policies that will reduce environmental pollution with

**Table 5: Long run coefficients. dependent variable: Emissions, ARDL (1, 2, 2, 0, 0)**

| Variable | Coefficient | Standard error | *t*-statistic | Prob |
|---|---|---|---|---|
| ΔlnENG | 2.144 | 0.658 | 3.256 | 0.003* |
| ΔlnPI | 0.123 | 0.065 | 1.897 | 0.070** |
| ΔlnFD | −0.017 | 0.111 | −0.155 | 0.878 |
| ΔlnGDP | −0.282 | 0.277 | −1.018 | 0.319 |
| C | −0.935 | 0.505 | −1.851 | 0.077** |

* and **represent 5 and 10% level of significance, respectively. ARDL: Autoregressive distributed lags, GDP: Gross domestic product

**Table 6: Short run coefficients. Dependent variable: Emissions, ARDL (1, 2, 2, 0, 0)**

| Variable | Coefficient | Standard error | *t*-statistic | Prob |
|---|---|---|---|---|
| ΔlnENG | 1.064 | 0.233 | 4.565 | 0.000* |
| ΔlnENG(-1) | −0.563 | 0.243 | −2.314 | 0.030* |
| ΔlnPI | 0.122 | 0.048 | 2.532 | 0.018* |
| ΔlnPI (-1) | 0.085 | 0.051 | 1.669 | 0.108 |
| ΔlnFD | −0.010 | 0.067 | −0.156 | 0.877 |
| ΔlnGDP | −0.170 | 0.148 | −1.156 | 0.262 |
| ECM(-1) | −0.602 | 0.162 | −3.726 | 0.000* |

*represents statistically significant at 5% l significance level. ARDL: Autoregressive distributed lags, GDP: Gross domestic product

little or no harm to economic variables. From the outcomes of this study, policy makers should give more attention to policies on private investment and energy consumption. This is owing to the fact that they contribute more to environmental pollution in Malaysia.

In conclusion, this paper investigated the impact of private investment, energy, aggregate output and financial development on $CO_2$ emissions in Malaysia between 1976 and 2013. The findings of the cointegration test established the incidence of a long-run connection between the variables. Furthermore, the coefficient of the long-run reveals positive effect of energy and private investment on environmental pollutions in Malaysia. Also, the short run ECM showed about 60% rate of adjustment back to the long run equilibrium. The study further recommended a more comprehensive policy on energy consumption and private investment in consideration of their effect on environment.

**Table 7: Diagnostic test of the ARDL model**

| Test statistics | *F*-statistics | Prob |
|---|---|---|
| Autocorrelation | 0.128 | 0.821 |
| Normality | 1.954 | 0.161 |
| Heteroskedasticity | 0.847 | 0.654 |

ARDL: Autoregressive distributed lags

**Figure 1:** Cumulative sum of recursive residuals

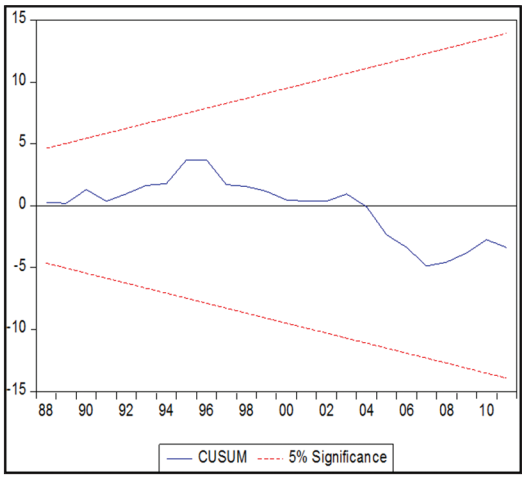
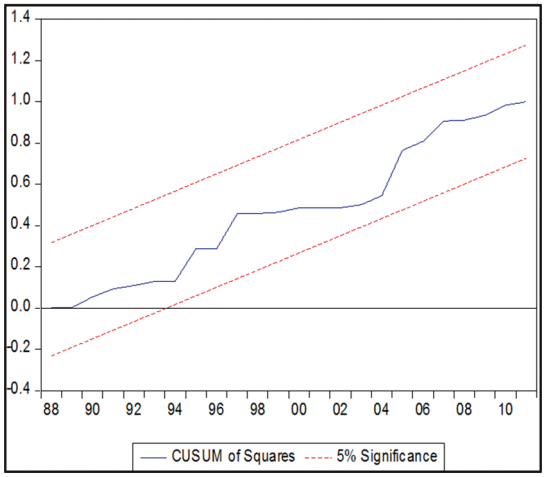



**Figure 2:** Cumulative sum of recursive residuals square

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