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Article

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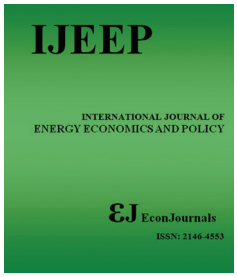

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The Effects of Electricity Consumption and Economic Growth on Carbon Dioxide Emission

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ABSTRACT

This study aims to investigate the effects of electricity consumption and economic growth on carbon dioxide emission in Malaysia from 1971 to 2013. The autoregressive distributed lag bound testing approach was employed and the results show that there are some effects of electricity consumption and economic growth on carbon dioxide emission in the long run. However, in the short run, the results show that there is no significant effect of electricity consumption and economic growth on carbon dioxide emission in Malaysia. Therefore the government should formulate several policies to ensure that the country can boost economic growth without any deleterious effect on the environment.

Keywords: Electricity Consumption, Economic Growth, Carbon Dioxide Emission
JEL Classifications: Q11, Q43

1. INTRODUCTION

Energy consumption plays an important role in determining economic growth. The recent increase in the global price of energy has perplexed researchers and thus the studies on energy consumption has been proliferating in developed and even developing countries (Shahiduzzaman and Alam, 2012; Amin and Murshed, 2017). Countries with a robust economy usually create an enormous demand for energy. Energy such as oil, gas and electricity is extensively consumed in numerous sectors such as manufacturing, transportation and services. By comparison with other energy types, electricity is consumed in all sectors. Therefore, electricity consumption is tremendously important to develop the economy. Ferguson et al. (2000) stated that as the electricity consumption rises, the economy is more prosperous. Shiu and Lam (2004) also agreed that as energy consumption intensifies, economic growth and standard of living is improved.

Despite the utmost importance of electricity consumption, all that glitters is not gold. This is because the use of electricity can be detrimental to the environment. To produce electricity, several energy sources such as oil and gas are used and these energy sources can result in carbon dioxide emission, ensuing environmental degradation. Salahuddin et al. (2015) stated that the rising electricity consumption can have the effects of spurring the economy to faster growth and at the same time carbon dioxide emission deteriorates. The issue of increasing global warming emerged owing to the increasing use of energy such as electricity (Gao and Zhang, 2014). Therefore to formulate the right policies to do a balancing act between economic growth and the environment. It is vital for policy makers to understand the relationship between electricity consumption and economic growth, and electricity consumption and carbon dioxide emission (Mezghani and Haddad, 2017).

Apart from that, the environmental Kuznet curve underlines the relationship between output and the environment. At the beginning stage, as economic growth is higher, the environmental degradation is larger. At the final state, as economic growth is higher, the environmental degradation is improved. This issue also has merited attention from previous researchers. Salahuddin et al. (2015) found that economic growth can also cause the environmental degradation to worsen. However Shahbaz et al. (2014) argued that economic growth can reduce the environmental degradation.

Due to the continuous complexity of the environmental issue, it is still important to investigate the effects of the electricity consumption and industrial output on carbon dioxide emission. Therefore, this study aims to shed some light on the issue by adding an empirical evidence on it.

2. LITERATURE REVIEW

To have better understanding of electricity consumption, several previous studies have been reviewed and can be divided into two categories. One is on the relationship between electricity consumption and economic growth only. Second is on the relationship among electricity consumption, economic growth and carbon dioxide emission. The previous studies that investigated the relationship between electricity consumption and economic growth are Shiu and Lam (2004); Bayar and Ozel (2014), Kasperowicz (2014); Sekantsi and Okot (2016); Zakaria and Shamsuddin (2016), Nguyen and Wongsurawat (2017) as well as Amin and Murshed (2017). They employed various methods and obtained mixed findings.

For example Shiu and Lam (2004) used Johansen cointegration and vector error correction model (VECM) to investigate the relationship between electricity consumption and economic growth in China. The study analysed data from 1971 to 2000 and the results showed that electricity consumption can cause economic growth to change, but economic growth does not cause any change in electricity consumption. Amin and Murshed (2017) extended the study of Shiu and Lam (2004) by using the same method (Johansen cointegration and VECM). However Amin and Murshed (2017) examined the relationship in a different country which is Bangladesh. Data from 1980 to 2013 were analysed and the results confirmed that electricity consumption does influence economic growth in two time horizons: Short and long runs.

The evidence of a relationship between electricity consumption and economic growth is supported by Bayar and Ozel (2014) who also found that electricity consumption can increase economic growth in emerging countries. The study used panel data analysis, employing panel cointegration, fully modified ordinary least squares (FMOLS), dynamic OLS (DOLS) and panel Granger causality to analyse data from 1970 to 2011. The study found that not only electricity consumption can influence economic growth but economic growth can also influence electricity consumption in those countries.

Kasperowicz (2014) investigated the relationship between electricity consumption and economic growth but the study was conducted using data from Poland. OLS was employed to analyse data from 2000 to 2012. The results also confirmed that electricity consumption can boost economic growth. Sekantsi and Okot (2016) also investigated the relationship between electricity consumption and economic growth in Uganda. Autoregressive distributed lag (ARDL) and Granger causality were adopted and data from 1981 to 2013 were collected. The results suggested that electricity consumption can influence economic growth with feedbacks.

Several studies included carbon dioxide emission in their studies as they were not only concerned about economic growth but also the environment (Lean and Smyth, 2010; Akpan and Akpan, 2012; Gao and Zhang, 2014; Shahbaz et al., 2014; Salahuddin et al., 2015; Mezghani and Haddad, 2017; Rosado, 2017).

With the variety of methods, mixed findings were obtained. Lean and Smyth (2010), Gao and Zhang (2014) and Salahuddin et al. (2015) used panel data analysis such as panel co-integration, FMOLS, DOLS, etc. Lean and Smyth, (2010) investigated the relationship among electricity consumption, economic growth and carbon dioxide emission in ASEAN countries while Gao and Zhang (2014) and Salahuddin et al. (2015) investigated in Sub-African countries and the Gulf Cooperation Council countries, respectively. Lean and Smyth (2010) found that electricity consumption can affect economic growth but not carbon dioxide emission. Gao and Zhang (2014) found that electricity consumption can affect carbon dioxide emission and vice versa. Salahuddin et al. (2015) found that carbon dioxide emission is dependent on electricity consumption and economic growth.

Mezghani and Haddad (2017) investigated the relationship among electricity consumption, energy consumption and carbon dioxide emission in Saudi Arabian. Johansen cointegration, VECM, Granger causality and impulse response were employed to analyse data from 1971 to 2010. The study found that high volatility in electric consumption (EC) can have undesirable effects on carbon dioxide emission in 1970's and 1980's.

3. METHODOLOGY

The main objective of this study is to investigate the effects of electricity consumption and economic growth on carbon dioxide emission in Malaysia. This study uses time series data from 1971 to 2013. The general model specification is as follows:

$$\ln CO_{2t}=\beta_0+\beta_1 \ln GDP_t+\beta_2 \ln EC_t+\varepsilon_t \quad (1)$$

Where, CO_2 refers to CO_2 emissions, EC refers to EC, GDP refer to gross domestic product, t refers to year and ε refers to error term and all the variables are in logarithm. In order to examine the existence of short- and long-run relationships, this empirical study employs the ARDL bounds testing approach. There are several advantages of using this method over the Johansen co-integration. One of them is a large data sample size is not necessary. Other than that it does not require all the variables to be of the same order of integration There are five tests that should be conducted to complete the ARDL data analysis. First is the boundary test which is to see the differences between F-statistic and critical values. If the F-statistic value is less than the critical value, then the null hypothesis is accepted and if the F-statistic value is larger than the critical value, then the alternative hypothesis is accepted (Hussin and Muzafar, 2008). Next, we estimate the long-run relationship between the dependent variable and independent using the ARDL technique. The relationship between independent variables and independent variables can be written as equation (2):

$$\Delta \ln CO_{2t} = \beta_0 + \beta_1 \ln CO_{2t-1} + \beta_2 \ln GDP_{t-1} + \beta_3 \ln EC_{t-1} + \beta_{4,i} \sum_{i=1}^{p} \Delta \ln EC_{t-i} + \beta_{5,i} \sum_{i=1}^{q1} \Delta \ln GDP_{t-i} + \beta_{6,i} \sum_{i=1}^{q2} \Delta \ln CO_{2t-i} + \beta U_t \quad (2)$$

Where, Δ is the first difference operator, equation (2) is an ARDL model known as a model (p, q1, q2). The Alkaike information criterion is used to select the lag and then, the ECM test is conducted to see the short-term relationship between independent variables with dependent variables and the equation can be written as follows:

$$\Delta \ln EC_t = \mu + \sum_{i-1}^{p} \phi_i \Delta \ln EC_{t-i} + \sum_{j-1}^{q1} \varphi_j \Delta \ln GDP_{t-j} + \sum_{k-1}^{q2} \gamma_k \Delta \ln CO_{2t-k} + ECT_{t-1} + \varepsilon_t \quad (3)$$

Where, φ and γ are dynamic coefficients for the short term while ECT_{t-1} is the speed adjustment for the long-term error correction.

4. RESULTS

This study uses the unit root test, employing the augmented Dickey Fuller to see the stationary of the data. The results of the unit root test are recorded in Table 1. Based on the table, the results show that all the variables are not significant at level and significant at first difference under intercept with and without trends. Therefore, these findings suggest that all the variables are stationary at level but not stationary at first difference. Then the bound test is conducted to determine the existence of a cointegration among the variables.

Table 2 shows the results of the bound test. The results suggest that F-statistic is larger than critical value at a significant value of 1%. It suggests that the alternative hypothesis of an existence of cointegration is accepted as the calculated F-statistic is larger than the upper bound critical value. Therefore it can be concluded that there is a long run relationship among the variables.

Table 3 shows the results of the estimated long run coefficient. The results suggest that electricity consumption can positively influence carbon dioxide emission in the long run as it is statistically significant at 5%. It suggests that a 1% increase in electricity consumption can cause carbon dioxide emission to increase by 0.003%. Apart from that economic growth can also have a positive effect on carbon dioxide emission in the long run as it is significant at 1%. Therefore, a 1% increase in economic growth can cause carbon dioxide emission to rise by 0.033%. Despite the existence of the effects of energy consumption and economic growth on carbon dioxide emission, their effects are very small.

Table 4 shows the short-run effects of electricity consumption and economic growth on carbon dioxide emission in Malaysia. The results show that electricity consumption and economic growth do not have any effect on carbon dioxide emission in the short run. Therefore, an increase in energy consumption and economic growth will not cause any change in carbon dioxide emission.

To see the goodness of the model, this study conducted several studies such as Breusch-Godfrey serial correlation test, Ramsey RESET stability test, Autoregressive conditional heteroskedasticity test and Jarque-Bera test. The results of all the tests are recorded in Tables 4 and 5. Based on the table, the results reveal that there is no serial correlation and the data is normally distributed. Apart from that the results also show that there is heteoscedasticity. The model is still good to explain the effects of electricity consumption and economic growth on carbon dioxide emission in Malaysia.

Table 1: Unit root test results

Variables	Intercept		Intercept and trend	
	Level	First difference	Level	First difference
$lnCO_2$	−2.254223	−5.280396*	−1.469420	−5.627100*
lnGDP	−1.934530	−5.394280*	−1.540104	−5.635373*
lnEC	−2.032343	−2.784890***	−2.444019	−3.329304***

*,**, and ***Significant at 1%, 5% and 10% significant respectively. GDP: Gross domestic product

Table 2: Bound test for the existence of a long run relationship

F-statistic: 13.45968		
Critical value		
Significance (%)	10 bound	11 bound
10	3.17	4.14
5	3.79	4.85
2.5	4.41	5.52
1	5.15	6.36

Table 3: Estimated long run coefficient using the ARDL approach

Variables	Coefficient	Standard error	P
lnEC	0.002940**	0.001402**	0.0443**
lnGDP	0.032781*	0.001674*	0.0000*
C	2.386540*	0.034740*	0.0000*

*, and **indicates significant at 1% and 5% significant level. ARDL: Autoregressive distributed lag, GDP: Gross domestic product

Table 4: Estimated short-run coefficients using the ARDL approach

Variables	Coefficient	Standard error	P
D(LNEC)	0.000199	0.000100	1.982332
D(LNGDP)	0.037622	0.000144	260.426477
D\(LNGDP(−1))	−0.003726	0.007352	−0.506773
D(LNGDP(−2))	0.013955	0.005375	2.596203
ECT(−1)	−0.067659	0.020379	−3.319981

ARDL: Autoregressive distributed lag, GDP: Gross domestic product

Table 5: Diagnostic tests

Test statistic	F-statistic (P)
Breusch-Godfrey serial correlation	1.226345 (0.3081)
Ramsey RESET stability	74.78607 (0.0000)
ARCH	2.831693 (0.0176)
Jarque-Bera	2.956337 (0.2281)

ARCH: Autoregressive conditional heteroskedasticity

5. CONCLUSION

This study aims to examine the effects of electricity consumption and economic growth on carbon dioxide emission in Malaysia. Data from 1971 to 2013 were collected and analyzed. The unit root test was conducted and the results show that all the variables used in this study are stationary at level and not stationary at first difference. Subsequently, the ARDL bound testing approach was applied and the results show that in the long run, electricity consumption and economic growth can have deleterious effects on the environment in Malaysia. However, their effects are very small. In the short run, electricity consumption and economic growth do not have any effect on the environment.

These finding are very important for policy makers to formulate the right policies. This is to ensure that economic growth can be enhanced and the environment can be simultaneously conserved. The use of renewable energy such as biomass and hydro, in generating economic activities is a good measure to achieve sustainable development.

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