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Analyzing Carbon Dioxide Emissions from Energy Resources

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Abstract: Recently, the awareness among the people and the government regarding the environmental problems has increased especially with the rise of CO_2 emissions worldwide. The increase of CO_2 emissions has intensified the greenhouse effect that leads to earth's surface temperature to rise and cause a global warming. Due to this, the Malaysian government has taken various initiatives to reduce the greenhouse effect by encouraging the use of low carbon energy resources such as solar, biomass, small hydro and natural gas. Hence, this study intended to examine the long run and the short run relationship between CO_2 emissions with high and low carbon energy resources in Malaysia based on ARDL bound testing approach using energy data from the year 1980 to 2009. The findings show that diesel and LPG as sources of fossil fuels have a long run and short run relationships with CO_2 emissions in Malaysia.

Key words: CO_2 emissions · High carbon energy · Low carbon energy · Bound testing approach

INTRODUCTION

In recent discussions on global warming, there are a lot of issues that have been highlighted by researchers and environmental activists especially on the carbon dioxide (CO_2) emission specifically from manufacturing and transportation industries and its effects on climate change. According to Human Development Report from United Nations Development Program [1], Malaysia contributed only 0.7 percent of global CO_2 emissions. However, a report from the International Energy Agency [2] showed an emissions intensity level for Malaysia is higher than the global average in the energy sector which is 1.3 tonnes of CO_2 per US $1000 GDP compared to 0.73 tonnes of CO_2 per US $1000 GDP for world average.

The global climate change is being affected by the emission of greenhouse gases (GHGs), of which the most significant is carbon dioxide (CO_2). Malaysia and many other countries have ratified the Kyoto Protocol and set long-term goals to reduce CO_2 emission in order to mitigate climate change. This aspiration has become a great challenge for Malaysia.

The CO_2 emissions (metric ton per capita) in Malaysia were reported at 6.57 in year 2004 and increase to 7.57 in year 2008. CO_2 emissions are those stemming from the burning of the burning of fossil fuels and the manufacturing of cement as stated in World Bank Report [3]. Additionally, Wee, *et al.* [4] discovered the total CO_2 emission in Malaysia for 2004 is slightly higher compared to the other developing Southeast Asian countries, which is the third highest after Indonesia and Thailand. Meanwhile, the total emission for Malaysia is only about 40 percent of Indonesia and 64 percent of Thailand. The per capita emission of Malaysia is about 3.5 and 1.6 times of the values of Indonesia and Thailand, respectively.

The continuous use of fossil fuels in the long run will increase the greenhouse gases (GHGs). Malaysia is aware of this problem and has acted accordingly by setting up a number of institutions that responsible in managing and promoting the use of cleaner energy. For example, the Ministry of Energy, Green Technology and Water (KeTTHA) was given the role to promote the use of low-carbon energy for the entire industry. Meanwhile, the

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Sustainable Energy Development Authority (SEDA) established in 2011 to identify the renewable energy (RE) that can be applied in the industry and be used efficiently. Due to the importance of CO_2 emission issue nowadays, this study intended to examine the long run and the short run relationship between CO_2 emissions with high and low carbon energy resources in Malaysia. This study will apply ARDL bound testing approach and utilize energy data from the year 1980 to 2009.

The remainder of the paper proceeds as follows: Section 2 briefly reviews the previous literature on CO_2 emissions worldwide. Section 3 outlines the methodology and data used in the study. Section 4 presents the empirical results from the analysis. Finally section 5 concluded the study.

Literature Review: The initial study that investigated the sources of CO_2 emissions to the atmosphere has been done by Baes *et al.* [5] using worldwide data from year 1958 to 1971. They found that fossil fuel consumption is a huge contributor to the GHGs effect. They suggested in order to overcome this problem, non-fossil fuel should be used especially by utilizing on solar energy. Meanwhile, Ogawa [6] discovered that global warming is now becoming one of the most important issues in international politics. CO_2 is estimated to have been responsible for 66 percent of the incremental greenhouse effect between year 1880 to 1980 and for 49 percent of the incremental greenhouse effect during the 1980s. Over the past century, fossil fuel burning was responsible for an estimated of 57 percent CO_2 emissions, 20 percent from forest destruction, 14 percent from natural sources and 9 percent from farming activities. Hence, the data revealed that fossil fuel burning is the major cause of global warming and certain action should be implemented to deal with this problem.

Gan and Li [7] developed a comprehensive econometric model to study the long-term forecasting of Malaysia's economy, energy and the environment until year 2030. Their projections indicated that Malaysia's gross domestic production (GDP) is expected to increase at an average of 4.6 percent from 2004 to 2030 and total primary energy consumption will triple by 2030. Coal import will increase following a governmental policy of intensifying its use for power generation. Oil import is predicted to take place by 2013 and reach 45 Mtoe in 2030. Hence, in the near future, Malaysia's energy import dependency will rise. CO_2 emissions are expected to be triple by 2030. This study discovered that the utilization of renewable energy is the best option to improve the long-term energy security and environmental performance for Malaysia. The government involvements and support especially through an establishment of an environmental regulation and enforcements are vital.

Romano and Scandurra [8] analyzed the investment in renewable energy sources, especially in low carbon and high carbon economies based on the data from 29 countries worldwide. They suggested if these countries want to achieve certain goal of carbon intensity, it can be achieved by improving the energy efficiency and changing the energy structure, such as investing in wind power, solar power or other renewable sources.

Meanwhile, Payne [9] examines the causal dynamics between renewable energy consumption, real gross domestic product (GDP), carbon emissions and real oil prices using the Toda-Yamamoto long-causality test procedure over the period of 1949 to 2009 in USA. The results indicated that renewable energy legislation and policies since 1978 had a positive and statistically significant impact on renewable energy consumption. The results also revealed that real GDP, carbon emissions and real oil prices did not have causal impact on renewable energy consumption. The relatively slow response of renewable energy consumption to real GDP and carbon emissions is not surprising given that renewable energy technologies and the market penetration and accessibility of renewable energy systems are still evolving. Their results also support the continuation of renewable energy policies as well as the development and use of renewable energy to replace fossil fuel energy sources.

Malaysia has taken various measures to overcome CO_2 emission in this country. Malaysia voluntary interested to reduce the CO_2 intensity per unit GDP by 40 percent in 2020. Malaysian government did not strict in applying taxation for polluters. Malaysia has their own recipes to monitor polluters or emitters. One of the methods is by introducing Environmental Quality Act 1974 and set-up institutions to handle that problems such as the Department of Environment (DOE), the Sustainable Energy Development Authority (SEDA), Ministry of Energy, Green Technology and Water (KeTTHA) and so forth. However, Mohamed and Lee [10] argued Malaysia is not ready to displace non-renewable energy with renewable energy. Even though, the implementation of various policies and programs by the government has increased the awareness of the people on the importance of renewable energy in achieving sustainable development.

Data Sources and Methodological Framework:

Data Sample: The annual data were collected from year 1980 to 2009. The data were obtained from World Development Indicators (WDI) and Energy Commission of Malaysia database. Basically, the resources of energy can be divided into two types. Low carbon energy sources consist of total liquid petroleum gas consumption (LPG), total hydro power consumption (HYDRO) and total liquid natural gas consumption (LNG). Meanwhile, high carbon energy sources consist of total diesel consumption (DIESEL), total fuel oil consumption (FUEL) and total motor petrol consumption (PETROL).

Estimation Techniques: The autoregressive distribution lag (ARDL) approach or the bound test approach adopted in this study was introduced by Pesaran *et al.* [11]. The ARDL bound test has several advantages compared to the Engle and Granger [12] or the Johansen and Juselius [13] type of cointegration method. First, the bound test can be implemented irrespective of whether the underlying regressors in the model are purely I(0), I(1) or mutually cointegrated. Second, the ARDL approach is able to examine the existence of the short-run as well as the long-run relationships between the independent variables and the dependent variable simultaneously. Third, the cointegration relationship can be estimated using the simple ordinary least square (OLS) method once the order of lags in the ARDL model is identified. Finally, the ARDL approach provides robust result when applied on a smaller sample size of cointegration analysis. Since the sample size in this study is small, therefore this provides additional enthusiasm for the study to adopt this approach.

An ARDL model is represented in equation (1) as follows:

$$\Delta \ln CO2=\alpha_0 + \sum_{J=1}^{K1}\alpha_1 * \Delta \ln CO_{2\,t-1} + \sum_{J=1}^{K2}\alpha_2\ \Delta \ln Fuel_{t-1} + \sum_{J=1}^{K3}\alpha_3\ \Delta \ln Diesel_{t-1} + \sum_{J=1}^{K4}\alpha_4\ \Delta \ln Petrol_{t-1} + \sum_{J=1}^{K5}\alpha_5\ \Delta \ln LPG_{t-1} + \sum_{J=1}^{K6}\alpha_6\ \Delta \ln LNG_{t-1} + \sum_{J=1}^{K7}\alpha_7\ \Delta \ln Hydro_{t-1} + \beta_1 \ln CO_{2\,t-1} + + \beta_2 \ln Fuel_{t-1} + \beta_3 \ln Diesel_{t-1} + \beta_4 \ln Petrol_{t-1} + \beta_5 \ln LPG_{t-1} + \beta_6 \ln LNG_{t-1} + \beta_7 \ln Hydro_{t-1} + \varepsilon_T \quad (1)$$

wheres:

CO_2 = Total carbon dioxide emission in
Fuel = Total fuel oil consumption
Diesel = Total diesel consumption
Petrol = Total motor petrol consumption
LPG = Total liquid petroleum gas consumption
LNG = And total liquid natural gas consumption
Hydro = Total hydro power consumption
α_n = The long run multipliers
β_n = The short run dynamics
ε_t = White noise error term

The above model will be estimated using the ARDL bound test in order to test that there is a cointegration relationship between CO_2 and types of energy resources. The ARDL bound test is based on the F or Wald-statistic, which has a non-standard distribution. Pesaran et.al [14] introduced two critical values to test for cointegration. The lower critical bound assumes all the variables are I(0), means that there are no cointegration among the variables, while the upper bound assumes that all the variables are I(1) means that there is a presence of cointegration among the variables. These can be denoted as:

H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = 0$ (There is no cointegration among the variables) H_1: $\beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq \beta_7 \neq 0$ (There is cointegration among the variables)

Based on the result of the F-test, if the computed F-test is higher than the upper bound, the null hypothesis of no cointegration is rejected. If the F-test is lower than the lower bound then the null hypothesis cannot be rejected. Meanwhile, if the F-test lies between the lower and the upper bounds, a conclusive inference cannot be made. Once the cointegration is confirmed and determined, the last step of the ARDL model to estimate the ARDL error correction model to evaluate the short run relationship and the speed of adjustment between CO_2 emission and types of energy resources. Finally, in order to ensure the model is an appropriate model, several diagnostic tests and stability test were carried out at the end of the analysis.

Empirical Estimation and Interpretation of the Results

Bound Testing: The results of bound test are shown in Table 1. Based on critical value from Narayan [15], the computed F-test (6.287) is greater than the critical upper value (5.691) as tested at 1% level of significance). Therefore, it can be concluded that the null hypothesis of no cointegration is rejected. Hence, it can be concluded that there is a long- run relationship between CO_2 emissions and the explanatory variables.

Table 1: Bound Test Based on Equation 1

Level of significant	Critical value Lower	Upper	Computed F-statistic for country Malaysia
1% Significance	3.976	5.691	6.2877*
5% Significance	2.794	4.148	
10% Significance	2.334	3.515	

Note: The critical values are taken from Narayan [15]. Table Case II, restricted intercept and no trend.* denote significant at 1% level of significance.

Table 2: Long Run Coefficient of CO_2 Emission and the Variables

Regressors	Coefficient (1,0,0,0,0,0,0)	t-stat
lnFUEL	-0.8369	-0.4365
lnDIESEL	1.1763**	2.0823
lnPETROL	-0.1824	-0.3406
lnLPG	0.3073***	1.8054
lnLNG	0.0051	0.0643
lnHYDRO	0.0015	0.0074
Constant	0.5997	0.5857

Note: Dependent variable Ln CO_2.
Figures inside the parenthesis are the value of t-ratios. *, ** and *** denotes significance levels at 1%, 5% and 10%, respectively.

Table 3: Error Correction Representation of ARDL Model

Regressors	Coefficient (1,0,0,0,0,0,0)	t-stat
ΔlnFUEL	-0.0354	(-0.4478)
ΔlnDIESEL	0.497**	-2.4497
ΔlnPETROL	-0.0771	(-0.3714)
ΔlnLPG	0.1296**	-2.1841
ΔlnLNG	0.0022	-0.0645
ΔlnHYDRO	0.0006	-0.0074
Ecm_{t-1}	-0.4226*	(-2.7947)
OLS Results:		
R^2	0.9904	
Adjusted R^2	0.9872	
F-statistics	309.7603*	
Diagnostic test:		
LM(N)	1.1261	
ARCH test	0.5844	
Stability test	Stable	

Note: Dependent variable Ln CO_2. Figures inside the parenthesis are the value of t-ratios. *, ** and *** denotes significance levels at 1%, 5% and 10%, respectively.

Long-Run Relationship: The results in Table 2 show long-run relationship for CO_2 determinants. The results showed that diesel significantly has a long-run relationship with CO_2 emission at 5 percent significant levels. The positive coefficient of diesel lends support to the view that the increase in diesel consumption in the long run will increase the CO_2 emissions in Malaysia.

The results in Table 2 also discovered that LPG contributes to CO_2 emission in the long run based on 10 percent significant levels. The coefficient of LPG consumption towards CO_2 emissions is positive revealed that an increase in consumption of LPG in the long run will increase the CO_2 emissions in Malaysia.

Short-Run Relationship and Speed of Adjustment: This study is further estimating short-run relationship and the error correction model. The results are presented in table 3. The results show that diesel and LPG have a positive relationship with CO_2 emissions in the short run at 5 percent significant levels.

As indicated in Table 3, the error correction model (ecm_{t-1}) measures the speed of adjustment to restore equilibrium in the dynamic model. The negative sign in the error correction model is statistically 1 percent significance level, thus confirming a long-run relationship exists among the variables. The error correction is -0.4426. The speed of adjustment is quite fast, ranging by about 42 percent. This result also indicated that last period disequilibrium is, on the average corrected by about 42 percent in the following year.

Finally, the results showed that this study passed the diagnostic tests for normality test using LM test and heteroskedasticity test based on ARCH test. The stability test also showed that there is no structural instability for this study.

CONCLUSION

Based on ARDL bound testing approach, this study found that diesel and LPG have a long run and short run relationship with CO_2 emissions. This is consistent with the findings from Quadrelli and Peterson [16] whereby fossil fuel is positively significant with CO_2 emissions.

In order to reduce CO_2 emissions in Malaysia, SEDA (Sustainable Energy Department Authority Malaysia) has identified four low-carbon energy sources that suitable to be used in the production process i.e. biogas, biomass, small hydro and solar photovoltaic.

Malaysia is committed to manage its energy resources, ranging from fossil fuels to renewable resources, on a sustainable basis. In this respect, the improvement of rules, regulation and enforcements should become a priority to the policy makers in order to reduce CO_2 emissions via low carbon energy resources. However, there are a number of challenges that exist in the process to use low carbon energy resources such as insufficiency in the volume of low carbon energy stock. In this regard, formulation of sustainable energy policies and strategies especially by the government, policy makers and the scientist are indeed a pre-requisite to promote the use of low carbon energies in this country.

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