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Research paper

The Impact of Selected Macroeconomic Variables on Carbon Dioxide (Co2) Emission in Malaysia

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Abstract

This study tries to investigate the relationship between gross domestic product, electricity product, net trade, electricity consumption and oil price on carbon dioxide (Co2) emission in Malaysia. Thus, it uses the Ordinary Least Square (OLS) method in structuring the model estimation. By utilizing yearly time series data from 1980 to 2017, this study focuses on economics and statistical criteria analyses. According to sign analysis, the results suggest that, gross domestic product, electricity product, net trade and energy consumption affect carbon dioxides (Co2) positively. In contrast, the oil price affects carbon dioxides (Co2) negatively. Furthermore, the results in statistical criteria conclude that the gross domestic product, electricity product and energy consumption are the dominant factors that influence carbon dioxides combustion in the long run in Malaysia.

Keywords: *Carbon Dioxide (Co_2), Gross Domestic Product, Macroeconomic Variables, Energy Consumption, Ordinary Least Square Model.*

1. Introduction

Climate change is the biggest threat to nature and humanity in the 21st century (Rahman, 2009). The climate change due to rising global temperature has been a great concern among researchers all over the world. One of the major threats created from the phenomenal changes is global warming (Ab-Rahim & Teoh, 2016). Global warming is caused by the effect of increasing average temperature of earth surface from over emitting of greenhouse gases such as carbon dioxide (CO2). The emission of CO2 and other gases will remain in the atmosphere for many years to come while making it almost impossible to eliminate. Should humans are unable to control the surge of global warming activities, we will witness the rise of sea levels rising due to The Arctic ice melting and even higher frequency of tropical storms hitting the earth in the future. There have been various studies focusing on the environmental issues and trying to restrain from severe global warming, as it may lead to serious matter.

Malaysia is one of the countries that depend on its land production to generate its national income. In Malaysia, National Policy in climate change has been enforced to provide a framework that could be used as guidance for all government agencies, industries, community as well as other stakeholders in order to face challenges in climate change scenario. The policy has been imposed to ensure climate-resilient development to fulfill national aspiration for the sustainability of its environment.

The imposed policy is mainly to control the climate change through wise management of resources and ameliorate environmental conservation resulting in strengthening Malaysian economic competitiveness and improved life quality of the nation. Therefore, all policymakers need to integrate and strengthen policies, plans and programs throughout the country for resilience development reinforcement while finding ways to eliminate any worse impact regarding climate change. To emphasize, strengthening institutional and implementation capacity will produce better opportunities to reduce the negative impact of climate change. Truthfully, climate change is not solely an issue concerning Malaysia but all countries worldwide, as well. In fact, it has become a global threat and need a global solution to mitigate the greenhouse gases emission. Researchers have been trying to assess the impact of climate change on crops in order to sustain food supplies. In Malaysia, by using adaptation strategy, including crop management, soil management, cap and trade the pollution (Co2) as well as irrigation management have been proposed to farmers in order to minimize the impact of climate change. Nevertheless, the major concern is still revolved around CO2 emissions, since this issue cannot be controlled by Malaysia alone. From previous studies, there are many methods used in reducing CO2 combustion.

Thus far, the aggregated potential mitigation of CO2 emissions in the manufacturing industry remains unclear. Prior to designing appropriate policies, a clear elucidation of potentially mitigating CO2 emission is necessary. As starter, the potential exoneration of CO2 emission of the manufacturing industry has been broadly discussed at that particular sector. Nonetheless, studies at industrial level on this subject are very rare.

Second, the changes in the emission factors of electricity and heat have been ignored in most industry-level studies, when estimating CO2 emission. Currently, the method proposed by the IPCC Guidelines for National Greenhouse Gas Inventories is widely adopted to estimate CO2 emission, which is mainly based on energy consumption and carbon emission factors (IPCC, 2006). Theoretically, the carbon emission factors of all types of energy

are changing over time due to advances and efficiency in energy utilization. In practice, changes in fossil fuel emission factors have been assumed to be constant because of data availability and tiny variations, whereas the changes in the carbon emission factor of electricity has been considered by many scholars (Mu et al., 2013; Wang et al., 2013). Unfortunately, the changes in electricity emission factor were neglected by most previous studies done.

Third, the emission coefficient effect has been ignored by most studies when analyzing the driving forces behind the change in CO_2 emission. Currently, the decomposition method has been widely applied to identify the factors influencing CO_2 emissions in the manufacturing industry (Diakoulaki and Mandaraka, 2007; Akbostancı et al., 2011; Hammond and Norman, 2012; Sheinbaum-Pardo et al., 2012). Based on the regression method, changes in CO_2 emissions can be utilized from many sectors, namely, macroeconomic, microeconomic, social-demography and many other factors.

2. Literature Review

Energy consumption has been increased all over the Association of Southeast Asian Nation (ASEAN) countries along with the continuous growth in their urbanization and industrialization (Ab-Rahim & Teoh, 2016). Study in the ASEAN countries and other three countries were conducted to investigate the determinants of carbon dioxide (CO2) emission since 1991 to 2010. In the study, researchers employ several types of models in their research methodology, including Panel Unit Root Test, the Pedroni (Eagle-Granger Based) Cointegration Test and the Granger-Casuality Test and the Vector Error Correction Model (VECM). These tests are run with selected variables by researchers such as total primary energy consumption per capita, total electricity net consumption, gross domestic product per capita, urban population, trade and the length of the road network in order to show its connection to the CO2 emission. Resulting from the Granger-Causality test, there is a bi-directional causality between CO2 emission and energy consumption. In the short-run, there are unidirectional causalities between economic growth, CO2 emission, energy consumption and trade openness. The same results of unilateral relationship apply to urbanization, electricity consumption and economic growth as well as trade openness, energy consumption and CO2 emission. Then, electricity consumption is unilaterally related to economic growth. Meanwhile, there is no causal relationship between transportation and other variables. It can be concluded that all variables can be used to determine the CO2 emission in the ASEAN+3 countries except for the length of the road network.

CO2 emission has been considered to be one of the most suitable indicators to design more effective global policies in preventing the climate change from getting even worst (Remuzgo & Sarabia, 2015). In recent years, there has been an increasing deployment of wind-powered generation technology in electricity networks across Europe (Curtis, Lynch & Zubiate, 2016). North Atlantic Oscillation (NAO) is a large-scale circulation pattern driving climate variability in northwestern Europe. A study by using Monte Carlo approach assesses the impact of NAO on CO2 emissions from the wider electricity system, generating hourly wind speed time-series data, electricity demand and fuel input data. The results confirm that there is a significant impact on monthly mean wind speeds, wind power output and CO2 emissions from the entire electricity system. It shows that CO2 emissions depend on the level of the wind penetration within the electricity system, but it also indicates that emissions intensity within the electricity system could be different depending on the NAO phases.

Moreover, the relationship between CO2 emission and the country financial development has been investigated several times in the past by researchers. Most of the studies argued that there had been positive relationship between CO2 emission and financial development. Soheilakhoshnevis and Bahram (2014) conduct their study in the long-run co-integration and short-run dynamics relation among CO2 emission, energy consumption, economic growth, urbanization, financial development and the country trade openness in Iran. The application of Auto Regression Distributed Lag (ARDL) is to test the approach of co-integration in the study and VECM Granger causality to examine the direct causal relationship. The findings reveal the existence of an environmental Kuznets curve in Iran for both in the short run and the long run. It also indicates that level of CO2 emission increases after some threshold level of income at the early stage of development. There is a possibility of the relationship changes from positive to negative as more efficient infrastructure and energy-efficient technology are implemented during the country development. In contrast, trade openness, financial development and urbanization are significantly responsible for the CO2 emissions in Iran. Causality tests indicate that there was a unidirectional Granger causality between real income per capita, energy consumption per capita, financial development and urbanization on CO2 emission per capita. Soheilakhoshnevis and Bahram later suggest that embracing more energy conversion policies need to be implemented for controlling CO2 emissions.

In addition, Tajudeen (2015) states that the efficiency of appliances and capital stock greatly determine the amount of energy demanded and the CO2 emitted. Energy demand is not only demanded for its own sake, however, it is indirectly offered through energy consumption appliances and capital stock services. This particular study is designed to examine the role of energy and non-economic factors such as consumers' preferences, lifestyle and value on energy demanded toward the CO2 emission. He finds that energy efficiency and non-economic factors are related to one another. In the context of long run output and price elasticity, significant differential had been stressed out from previous studies that had those factors ignored. In the sense of developing technology, this modern era will produce more energy demanded. Yet, current policies are not enough to mitigate the aggregate CO2 emission. Policy makers need to be aware of and should extend the new policies to restrain CO2 emission along with the previous policies that had already influenced the consumers' lifestyle and behavior. Developing energy efficient technologies and application of low tariffs on imported energy would have mitigated CO2 consumption and emissions.

Gavenas, Rosendahl and Skjerpen (2015) claim that emissions from oil and gas extraction are vital for fossil fuels. As a matter of fact, it accounts for significant shares of domestic emissions in many fossil fuels exporting countries all over the world. A study in Norway is conducted to empirically investigate the driving forces behind the intensity of CO2 emission in the Norwegian oil and gas extraction. The study is using field-scientific data that covers all airline oil and gas activities. It is found that CO2 emission per unit of extraction increases significantly as a field's extraction declines. This negative relationship causes the intensity of CO2 emissions increases significantly with the field's share of oil in the total of oil and gas reserves. They also find that oil and price for CO2 may have affected the emission intensities on that airline continental shelf. They take some variables into the matter of this study. The first variable is annual production as a share of the field's historic peak production, follows by the share of gas in the field's original reserves, the share of gas in the field's running production after the elimination of the original reserves, the original reserve size, reservoir depth, ocean depth, water produced as a share of peak oil and gas production, the price of CO2, the price of oil, electrified fields, first year of the extraction and the time trend. CO2 emission per unit of oil and gas production in that country varies substantially across field and over time. The size of reserves, reservoir, ocean depths and the field's starting year show no significant effects to the emission intensities. However, water production and the electrified field are highly significant when included into the model in this study.

Larger companies require thousands of employees to travel from one place to another, thus there will be heavily increase in the usage of cars. Consequently, the situation causes a wide range of problems such as CO2 emission to the atmosphere, noise pollution and parking issues (Bruck et. al., 2016). Besides government, every individual and every party need to be well aware of the consequences of human activities toward the environmental issues. In 2010, the Beijing Government launched a policy on vehicle ownership restriction due to faster motorization and excessive vehicle CO2 emission (Li & Jones, 2015). A study to analyze the policy implemented is conducted in order to project its effect on private passenger vehicle population in three situations, specifically no constraint (NC), current constraint (CC) and tighter constraint (TC). The study takes into consideration the amount of emission from vehicle types, the passenger vehicle population, average emission factors for vehicle types, annual average vehicle kilometers travelled and the total amount of emissions from all private passenger vehicles. Towards the end of the study discussion, the study summarizes that ownership restraints and driving restrictions are effective in controlling the growth of private passengers, which lead to CO2 emission to plummet. Considering the incoming improvement of fuels in the future, it may decrease the emission factors of CO2 emissions.

The manufacturing industry is one of the main CO2 emission contributors to the global fossil fuels consumption (Yan & Fang, 2015). The Chinese manufacturing industry had shown a spectacular growth of the China gross economic output value since the 1990s. The growth corresponds to the increase of total fossil fuels consumption, which also lead to the growth of the CO2 emission, substantially. The study investigates the influencing factors of CO2 emission changes within the Chinese manufacturing industry. The study also utilizes the Logarithmic Mean Divisa Index (LMDI) method. At the same time, the study explores the potential mitigation based on scenario analysis. Even though it shows that CO2 emission is growing, the unsteady growth is projecting a downward trend of CO2 emission intensity. Coal-dominant emissions structure and electricity-dominant emissions structure are subjected to CO2 emission intensity, as well. The three main sectors that contribute the most in CO2 emission are the smelting and pressing of ferrous metals, manufacture of raw chemical materials and chemical products and the manufacture of non-metallic product. These sectors contribute approximately around 60% of the total CO2 emissions from the fuel consumption. The economic scale is the major factor in CO2 emissions while energy intensity is the most important diminishing factor in CO2 emissions. Contrastingly, the effects of the emission coefficient, energy structure and economic structure are extremely small. The future of CO2 emissions depends on the decline in energy intensities in emission coefficient of electricity, together with the improvement in economic structure.

3. Model Specification and Findings

Following the modeling proposed by Curtis, Lynch & Zubiate (2016) and Norimah, et. al. (2017), the augmented structure of model specification for this study is as follows;

General Model

$$CO2_t = \beta_0 + \beta_1 GDP_t + \beta_2 ENRC_t + \beta_3 TRADE + \beta_4 ELEC_t + \beta_5 PRICE_t + \varepsilon_t \quad (1)$$

Estimation Model

$$CO^2_t = -8.023 + 0.415 GDP_t + 0.915 ENRC_t + 0.193 TRADE + 0.318 ELEC_t - 0.105 PRICE_t \quad (2)$$

Se		(1.102)	(0.087)	(0.245)	(0.122)	(0.078)	(0.044)
t-tes	(-7.279)	(4.742)***	(3.738)***	(1.580)*	(4.063)***	(-2.404)**

$R^2 = 0.982$

$F-test = 286050$

$DW-test = 1.490$

Where,

CO^2_t = Carbon dioxide emissions in Malaysia
GDP_t = Gross Domestic Product for the year *t*
$ENRC_t$ = Total of electricity production for the year *t*
$TRADE_t$ = Net trade for the year *t*
$ELEC_t$ = Energy consumption for the year *t*
$PRICE_t$ = Oil Price for the year *t*
ε_t = Error term
t = Annual data from 1980 to 2017
β_i (i=0,1,2,3,4,5) = Coefficient/magnitude

Notation:
***:Important at 99% confidence level
**:Important at 95% confidence level
*:Important at 85% confidence level

Equation (2) shows results of the estimated model.

In general, the results suggest that the gross domestic product, electricity production and energy consumption are the most influence variables that affect the carbon dioxide emission in the long term in Malaysia. The estimated model has also passed all the diagnostic testing procedure including multicollinearity test, autocorrelation test and heteroscedasticity test.

Accordingly, gross domestic product, electricity production and energy consumption affecting carbon dioxide emission at 99 percentage level of significance. The results further suggest that oil price and net trade are significant at 95 percentages and 85 percentages, respectively.

Moreover, there are two statistical tests performed, namely the student's t–test (t-test), and the Wald test (F-test). T-test is conducted is to verify whether each of independent variables individually is significant in explaining the dependent variable (CO_2), while the F-test is testing the goodness of fit for estimated model.

The critical value from statistical table is 2.074 for two tail test ($t_{\alpha/2} = 2.074$). Table 1 demonstrates the results for t-test procedure;

Table 1: Results for t-test procedure

Variable	Hypothesis	Statistical Test	Critical Value	Result
GDPt	$H_0 : \beta_1 = 0$ $H_1 : \beta_1 \neq 0$	4.742	2.074	*Reject H_0*
ENRCt	$H_0 : \beta_1 = 0$ $H_1 : \beta_1 \neq 0$	3.738	2.074	*Reject H_0*
TRADEt	$H_0 : \beta_1 = 0$ $H_1 : \beta_1 \neq 0$	1.580	2.074	*Accept H_0*
ELECt	$H_0 : \beta_1 = 0$ $H_1 : \beta_1 \neq 0$	4.063	2.074	*Reject H_0*
PRICEt	$H_0 : \beta_1 = 0$ $H_1 : \beta_1 \neq 0$	-2.404	2.074	*Reject H_0*

The statistical test value of t-test (t^*) for GDP_t = 4.742, which is greater than its critical value ($t_{\alpha/2} = 2.074$) with α equals to 5%, thus, H_0 is rejected. Hence, gross domestic product is important in explaining CO_2 emission in Malaysia in long run. In other words, if gross domestic product rises, concurrently, it will lead CO_2 to rise. The same outcomes apply for the other three variables, namely, $ENRC_t$, $ELEC_t$ and $PRICE_t$. In contrast, the statistical test value for $TRADE_t$ = 1.580 is smaller than its critical value, thus, we accept Ho. Accordingly, $TRADE_t$ is not an important factor in explaining CO_2 emission in Malaysia.

Table 2: Results for F-test procedure

Model	Hypotheses	Statistical Test	Critical Value	Result
Estimation Model	$H_0 : \alpha_1 = \alpha_2 = 0$ $H_1 : \alpha_1 \neq 0$	$F^* = \frac{\frac{ESS}{df}}{\frac{RSS}{df}} = 286.050$	3.78	2452.024>3.78 *Reject H_0*

Table 2 shows results for F-test (Wald test). According to the result, the estimated modeling is adequate. The statistical results support to reject the hypothesis null. Thus the combinations of independent variables are significant in explaining the dependent variable at 99%.

4. Conclusion

Overall, carbon dioxide (CO_2) emission is an important issue to be discussed. A lot of studies have been done in finding the best solution to control this issue. Of course, climate change only exists in Malaysia, but in other nations, too. It is recognized as a global problem and therefore, it requires a global solution to mitigate the driving greenhouse gas emissions. Based on the results, among other solution, one of the best ways to control the CO2 emission in atmosphere is through controlling the usage of oil at macro level. My point being, the oil price gives the negative impact on CO_2 emission in the long run. In other words, if oil price increases, thus the usage capacity of oil at macro level will decline (people, in aggregate, will not consume much oil since the oil becomes more expensive) and finally, it will lead to a reduction in CO_2 emission. Using adaptation strategy, National Policy in climate change in Malaysia has been formulated to provide a framework that could be used as a guidance for all government agencies, industry, community as well as other stakeholders in order to face challenges in climate change scenario. The policy has been enforced to ensure climate-resilient development in fulfilling national aspiration for our nation's sustainability and well-beings.

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