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Carbon Dioxide Emission, Energy Consumption, Economic Growth, Population, Poverty and Forest Area: Evidence from Panel Data Analysis

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ABSTRACT

This paper investigated the impact of energy consumption (EC), economic growth, population, poverty, and forest area on carbon dioxide (CO_2) emissions by using the econometrics approaches for Malaysia, Indonesia and Thailand. In this paper, it involved time series data over the period of 20 years from 1991 to 2010. There were several tests that had conducted which involved Panel unit root test, cointegration test, Granger causality test. From the empirical result, we found that the variables had more than one panel unit root tests. Cointegration test also showed that there was at least four cointegrating equation exist in the variables. For the Granger causality test, there was only poverty had unidirectional relationship with CO_2 emission, while the other variables were independent to the CO_2 emission. Testing approach showed that EC and economic growth had positive relationship with CO_2 emission. On the other hand, population growth rate had a little impact on CO_2 emission. However, poverty and forest area had negative relationship with the CO_2 emission. Thus, the economy substantially would try to tend to develop renewable energy and energy efficient to minimize the CO_2 emissions in order to enhance the long-run economic growth in Malaysia, Indonesia and Thailand.

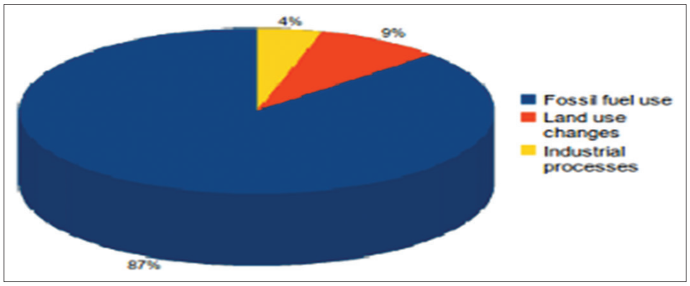
Keywords: Energy Consumption, Economic Growth, Carbon Dioxide Emissions, Population, Poverty, Forest Area
JEL Classifications: C33, O13, Q43

1. INTRODUCTION

Carbon dioxide (CO_2) is a heavy colourless gas that formed by burning fuels, it can be occur by burning of animal and plant, and by the act of breathing and absorbed from the air by plants in photosynthesis. Over the 21st century, atmospheric keep damaged due to increasing of greenhouse gases (GHG). The GHGs keep increasing because the human start to increase their human activities. The human activities include activities production, burning of fossil fuels, oil and natural gas and deforestation. Human ignore to care about the environment when they start to running their activities. CO_2 leads to the earth to warm. The climate changes due to the increasing of CO_2 and it resulting in occur global warming. Another negative climate impacts include heavy rainfall, flooding, glaciers melt, lack of water supply, sea level increase, etc. Since the revolution of industrial from agricultural sector, CO_2 emissions have been growing rapidly due to the human activities (Hasan, 2007).

Based on the Figure 1, showed, 87% of carbon dioxide emissions come from the burning of fossil fuel used by human for running activities. The fossil fuel use is the largest part of whole human sources of carbon dioxide (Jain et al., 2013). For examples they use in power cars, planes, industrial facilities and plants which is included in transportation sector and electricity sector. The 9% of carbon dioxide emission come from industrial processes and the remaining is come from land a use change which is 4%. Land use changes occur when the natural environment is used by human for agricultural land or settlements. Besides that, there are some main source of carbon dioxide emissions in industrial processes such as production and consumption of mineral products, production of metals, production of chemicals and petrochemical products. Apart from that, carbon dioxide emission also released by natural processes such as soil, plants, animals, earth’s oceans and volcanoes.

Figure 1: Human sources of carbon dioxide



Source: The global carbon budget, (1959-2011)

In Malaysia, government is setting a voluntary target which is reducing the carbon dioxide emission as well as this target can achieving in insight 2020 (New Economic Model for Malaysia, 2009). From previously century, Malaysia's economic shifted from agricultural sector to industrial sector, the energy consumption (EC) was rose rapidly. Currently, the developing of economic in Malaysia is more on services sector such as transportation, hospitality, foreign direct investment and tourism sector. The highly EC in services sector will slow down the achieving of reduction 40% carbon dioxide emission. For other example, Energy use per capita for Thailand in 1995 is 878 kg, followed by Indonesia is 442 kg per capita (World Bank, 1998). The EC will keep increasing rapidly if human do not take any effective action. So, the economy substantially will try tends to develop renewable energy and energy efficient.

Based on the study, we do the research about which variables will influence the changes of carbon dioxide emission in Malaysia, Thailand and Indonesia from 1991 years to 2010 years. Our objective is estimate the variables which is EC, economic growth, population, poverty and forest area in Malaysia, Thailand and Indonesia whether each variable will influence the changes of carbon dioxide emission or how many percentage of changes carbon dioxide emission can be explained by each variable given. There have 3 result will be estimated, whether the changes of carbon dioxide emission occur positive relationship between each variable, negative relationship or no relationships between each other. Based on the final estimation result, we will see that which variables have most impact for the changes of carbon dioxide emission. Through this result, government can set some useful policies to reduce the carbon dioxide emission following the variables given in order to minimize the carbon dioxide emission in Malaysia, Thailand and Indonesia. There are some strategies to reduce the carbon dioxide emission such as energy efficiency, energy conservation, fuel switching and carbon capture and sequestration. In helping us to complete the research, we need some test run to test our data and prove it the result is correct or not. For examples, the research method includes Panel unit root test, cointegration test, Granger causality test, vector autoregression estimates, panel least squares, heteroskedasticity test, autoregression test and so on.

The aim of this study is to show the relationship among carbon dioxide emission, EC, economic growth, population, poverty rate and forest area are some of the variables that we can examine and test in the study. This study also attempts to analyze the relationship among carbon dioxide emission, EC, economic growth, population, poverty, and forest area for the three ASEAN countries, which are Malaysia, Indonesia, and Thailand by using time series analysis.

2. LITERATURE REVIEW

There are many research and studies showed the empirical evidence that investigated the relationship between carbon dioxide (CO_2) emissions and economic growth among countries including developed and developing countries. Above studies involve countries such as OECD countries (Saboori et al., 2014), Brazil, Russian Federation, India, and China countries (Pao and Tsai, 2011), MENA countries (Arouri et al., 2012), industries-based countries (Hossain, 2011) and small economy scope countries (Fried and Getzner, 2003). However, there are studies which concentrated on a single country only. For instance, it showed the relationship among CO_2 emissions, EC and economic growth in China (Wang, et al., 2011).

Based on the theory, the initial stage of the economic development is represented by the Environmental Kuznets Curve (EKC). This curve shows a positive relationship between environment problems and little portion of the extra income achieved through the industrialization (Grossman and Krueger, 1995). The invented U-shaped EKC curve shows that a rise in the economic growth reduces the CO_2 emissions (Selden and Song, 1994; Al-Mulali et al., 2015; Shahbaz et al., 2015), but the U-shaped EKC curve indicates that increasing economic growth rate will generate more CO2 emissions which lead to environment degradation (Clausen and York, 2008). In addition, there was a study shows an N-shaped curve between CO_2 emissions and economic growth (Shafik, 1994). A study also found that there is no causal relationship between CO2 emissions and gross domestic product (GDP) per capita (Ozturk and Acaravci, 2010).

In developing countries i.e. Malaysia, there is hardly to find research on the dynamic effects between CO2emission, EC, economic growth, population, poverty and forest area. According to Saboori et al. (2012), he found that the EKC curve happened in Malaysia from 1980 to 2009. Despite this relationship, Malaysia government also implemented developing policies like public transport and green energy program which have reduced the emission of CO_2. Another study has showed an average of 4.6% increase in the expected GDP growth of Malaysia between 2004 and 2030. This is probably because of reduction in the output of agriculture sector by 3% and an increase in the output of industrial and service sectors over this period. At the same time, EC also rose by 4.3% in 2030 due to the economic growth rate. However, the absolute EC growth rate might be 3 times greater than the than the economic growth rate (Gan and Li, 2008). Besides, electricity as power sector has become a main contribution to the CO_2 emission and EC in Malaysia. An empirical result shows that electricity has accounted around 36% of the total global CO_2 emission in 2004 (Energy Information Administration, 2006).

According to the Stern (2006), the second main source that contributes to the emission of CO_2 is deforestation which driving climate change and global warming. There are a few of countries proposed a mechanism to compensate countries to reduce their deforestation and degradation and conserving the forest areas. Malaysia government also contribute its commitment to the forestry instruments such as reduced emissions from deforestation and forest degradation and clean development mechanism. By implementing these programs, the emission of CO_2 can be minimize through reducing the deforestation and managing the forest logging in order to support the global effort in reducing GHG.

Based on Figure 2, the population growth rate has a negative relationship with other variables such as CO_2 emissions, EC and GDP per capita from 1970 to 2010. Figure 2 clearly indicates that the variables including CO_2 emissions, EC and GDP per capita are keep rising, but the population growth rate are reducing gradually in above mentioned period.

One of the main factors that contribute to GHG is the emissions of CO_2 which lead to the global warming and climate change around the world. According to the National Hydraulic Research Institute of Malaysia (2011), climate change happened in the North East region of Peninsular Malaysia compared to the other regions. This is probably because of the substantial rise in the temperature and rainfall in this North East region including Terengganu, Kelantan, Perlis, Kedah and Perak. Based on this study, these regions are the most possible vulnerable states in the aspect of hard core poverty due to the climate change (GHG effects). This research proves that the people who living in such regions are poor and hard core poor which affected by the climate change.

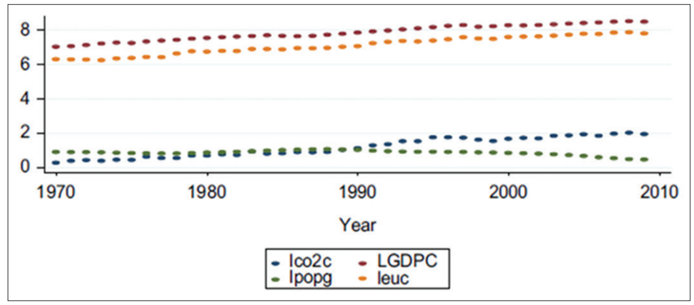
EC considered a fundamental driver of output, has a significant role in economic growth and development. It is a vital component in economic growth either directly or as a complement to other factors of production. Energy demand can influence international trade, while trade can also influence energy demand. In the first case, energy demand can influence trade because energy is an imperative input into the production and shipping of goods intended for international trade (Abidin et al., 2015).

Household EC refers to the amount of energy resources that are being spent by households on various appliances used by the households. The household EC pattern can be majorly categorised into dimensions such as; cooking, lightening, heating and cooling, as well as transportation purposes. An analysis of the pattern and determinant of household EC has been the focus of previous studies with different tools of econometric analysis, depending on the scope of the dimension of household EC covered by a study (Danlami et al., 2015).

A study on CO_2 emissions can be categorised into three main groups. The first categories are those studies that tested the validity of EKC hypothesis. The second categories are those that lay emphasis on the relationship between economic growth and CO_2 emissions. The third categories are those studies that lay emphasis on the simultaneous impacts of GDP and EC on CO_2 emissions (Danlami et al., 2017a).

Biomass as the source of cooking fuel is one of the causes of indoor air pollution, desertification, soil erosion and other visual

Figure 2: Logarithmic trend of CO2 emissions, energy consumption, gross domestic product per capita and population growth rate



Source: Begum, et al., 2015

problems. Analysing the patterns of household energy use in Bauchi State can enable the relevant authorities to have a clear picture and understand the factors that can shape the pattern of household energy choice in the state in order to encourage the households to adopt cleaner energy sources (Danlami et al., 2017b).

From above literature reviews, it builds a better understanding on the relationship among CO_2 emission, EC, economic growth, population, poverty and forest area in controlling and managing the emissions of CO_2 in Malaysia. This research and studies play an important role in providing the proper information and suggestions to the government policy makers to make decisions in order to achieve sustainable economic growth without degrading the environment in Malaysia.

3. RESEARCH METHODOLOGY

3.1. Model

In this paper, using the same method that proposed by Ang (2007) for a panel of Central American Countries, and Apergis and Payne (2010) for a panel of the Common-wealth of Independent States. The following model shows the long-run relationship between CO_2 emission, energy power consumption, economic growth, population, poverty and forest area.

$$CO_{2it}=\alpha_{it}+\beta_{1i}EPC_{it}+\beta 2_{i}GDP_{it}+\beta_{3i}POP_{it}+\beta_{4i}POV_{it}+\beta_{5i}FA_{it}+\varepsilon_{it}$$

Where,
i=1,…, N for each country in the panel
t=1,…, T for the time period
CO_2=Carbon dioxide emissions (kt)
EPC=Enery power consumption (kWh)
GDP=GDP growth (annual %)
POP=Population (total)
POV=Poverty headcount ratio at national poverty lines (% of popuplation)
FA=Forest area (km squares)
ε=Error or disturbance term.

β_1, β_2, β_3, β_4, β_5=Long-run elasticity estimates of CO_2 with respect to EPC, GDP, POP, POV and FA respectively.

Based on the EKC hypothesis, the model should expect that β_1, β_2 and β_3 > 0 where the increase in the energy power consumption, economic growth and population will lead to an increase in the carbon dioxide emissions. However, the model also should expect β_4 and $\beta_5 < 0$. This is probably because it reflects the inverted U-shape pattern while poverty and forest area pass the threshold. This indicates that an increase in poverty and forest area will lead to an increase in the carbon dioxide emissions.

The data sources in this paper are based a panel of three countries which involves Indonesia, Malaysia and Thailand over the 20 years period of time from 1991 to 2010. From these data resources, the sample is based on those three countries where the data on CO_2 emission, energy power consumption, economic growth, population, and forest area is available and can be obtained from the World Bank for this period. However, this paper only can obtain few poverty data resources for certain year due to limited data resources on poverty.

After forming the econometric model, this paper have to test whether there is an existance of long-run and dynamic causal relationships between CO_2 emission, energy power consumption, economic growth, population, poverty and forest area. The procedures involve in this testing contain of three steps which are panel unit root test, panel cointegration tests and panel Granger causality tests. In conducting these three types of tests, the procedures involved must be taken step by step.

3.2. Panel Unit Root Tests

To identify the stationary properties of the variables in this paper, the panel unit root tests are the first procedure to be conducted in panel data analysis. Besides, there are many methods for panel unit root test in panel data analysis. In this paper, there are three panel unit root test being conducted which are Im et al. test (2003), Maddala and Wu (MW) test (1999) and Breitung test (2000) in order to enhance the credibility of the results. By implementing Im, Pesaran and Shin (IPS) test, the serial correlation of the model can be eliminated and take heterogeneity among the sections into account. Thus, the IPS test has a very strong ability in testing the small samples. On the other hand, the MW tests are able to use different lags during the individual Augmented Dickey–Fuller (ADF) test.

In the view of Maddala and Wu (1999), it criticized the IPS test (2003) on many of the basis real world applications. IPS test proposed that the cross correlations can be effectively eliminated by demeaning the data, while Maddala and Wu (1999) proposed that the cross correlations are unlikely to take the simple form. Besides, it also proposed a panel ADF unit root test based on Fisher (1932). At the same time, the Fisher ADF test actually combines the p-values of the test statistic for a unit root in each residual cross-sectional unit.

Null hypothesis (Hn)=unit root exists.

Alternative hypothesis (Ha)=unit root does not exist.

In testing panel unit root tests, the null hypothesis of above mentioned unit root tests is that there is unit root exists in the model. However, the alternative hypothesis is that unit root does not exist in the model. In other word, the null hypothesis indicates that the variables non-stationary in the model. While, the alternative hypothesis shows that the variables are stationary in the model.

3.3. Panel Cointegration

After the testing in panel unit root test, we need to proceed with the second test which is to examine whether there is a long-run relationship between the variables. There are many types of testing procedures available to testing the panel cointegration such as Maddala and Wu (1999), Kao (1999) and Pedroni (1999, 2004). In this paper, the testing procedure of Maddala and Wu (1999) was used in analysing the panel cointegration. In this testing procedure, the Johansen Fisher panel cointegration test is proposed by Maddala and Wu (1999).

The Johansen Fisher panelcointegration test is referring to a panel version of the individual Johansen cointegration test (1988). One of the advantages in using the Johansen Fisher panel cointegration is its flexibility. Besides, Johansen Fisher panel cointegration is simple to implement and provides intuitively appealing. In addition, Hanck (2009) had conduct a similar research which found that the Johansen Fisher panel cointegration test performs better compared to the other alternative cointegration test proposed by Pedroni (2004), Kao (1999) and Larsson et al. (2001). The Johansen Fisher panel cointegration test aggregates the p-values of individual Johansen maximum eigen value and trace statistics based on the explanation and elaboration of Fisher ADF panel unit root test mentioned above. For the null hypothesis in this panel, the πi is the p-value from an individual cointegration test for cross-section *i*, then it can be represented as below:

$$-2\sum_{i=1}^{N}\log(\pi i)x^2 2N$$

Theorically, the value of the Chi-square statistic is based on the MacKinnon et al. (2001). p-values for Johansen’s cointegration trace test and maximum Eigen value test. In contrast, the results are known to depend heavily on the VAR system lag order for the Johansen-type panel cointegration test.

3.4. Panel Granger Causality

In penal cointegration, the Johansen Fisher panel cointegration test found that there is an existence of a long-run cointegrating vector which implies the existence of Granger causality, at least in one direction. In contrast, the Johansen Fisher panel cointegration test does not show the direction of causality (1980; 1988). To infer the Granger causality among the variables, the Granger causality test is based on the regressions as below:

$$\Delta CO_{2it} = \pi_{1i} + \sum_{p}\pi_{11i}\Delta CO_{2it\text{-}p} + \sum_{p}\pi_{12i}\Delta EPC_{it\text{-}p} + \sum_{p}\pi_{13i}\Delta GDP_{it\text{-}p} + \sum_{p}\pi_{14i}\Delta POP_{it\text{-}p} + \sum_{p}\pi_{15i}\Delta POV_{it\text{-}p} + \sum_{p}\pi_{16i}\Delta FA_{it\text{-}p} + \varepsilon_{1it}$$

$$\Delta EPC_{it} = \pi_{2i} + \sum_{p} \pi_{21i}\Delta CO_{2it-p} + \sum_{p} \pi_{22i}\Delta EPC_{it-p} + \sum_{p} \pi_{23i}\Delta GDP_{it-p} + \sum_{p} \pi_{24i}\Delta POP_{it-p} + \sum_{p} \pi_{25i}\Delta POV_{it-p} + \sum_{p} \pi_{26i}\Delta FA_{it-p} + \varepsilon_{2it}$$

$$\Delta GDP_{it} = \pi_{3i} + \sum_{p} \pi_{31i}\Delta CO_{2it-p} + \sum_{p} \pi_{32i}\Delta EPC_{it-p} + \sum_{p} \pi_{33i}\Delta GDP_{it-p} + \sum_{p} \pi_{34i}\Delta POP_{it-p} + \sum_{p} \pi_{35i}\Delta POV_{it-p} + \sum_{p} \pi_{36i}\Delta FA_{it-p} + \varepsilon_{3it}$$

$$\Delta POP_{it} = \pi_{4i} + \sum_{p} \pi_{41i}\Delta CO_{2it-p} + \sum_{p} \pi_{42i}\Delta EPC_{it-p} + \sum_{p} \pi_{43i}\Delta GDP_{it-p} + \sum_{p} \pi_{44i}\Delta POP_{it-p} + \sum_{p} \pi_{45i}\Delta POV_{it-p} + \sum_{p} \pi_{46i}\Delta FA_{it-p} + \varepsilon_{4it}$$

$$\Delta POV_{it} = \pi_{5i} + \sum_{p} \pi_{51i}\Delta CO_{5it-p} + \sum_{p} \pi_{52i}\Delta EPC_{it-p} + \sum_{p} \pi_{53i}\Delta GDP_{it-p} + \sum_{p} \pi_{54i}\Delta POP_{it-p} + \sum_{p} \pi_{55i}\Delta POV_{it-p} + \sum_{p} \pi_{56i}\Delta FA_{it-p} + \varepsilon_{5it}$$

$$\Delta FA_{it} = \pi_{6i} + \sum_{p} \pi_{61i}\Delta CO_{2it-p} + \sum_{p} \pi_{62i}\Delta EPC_{it-p} + \sum_{p} \pi_{63i}\Delta GDP_{it-p} + \sum_{p} \pi_{64i}\Delta POP_{it-p} + \sum_{p} \pi_{65i}\Delta POV_{it-p} + \sum_{p} \pi_{66i}\Delta FA_{it-p} + \varepsilon_{6it}$$

4. RESULTS AND DISCUSSION

4.1. Panel Unit Root Test

Unit root test is one of the most popular tests, it testing the stationary of the variables. It is simple and clearly used by the politician, economist, and econometrician. There are 3 unit root tests used in this study which is W-stat IPS, Breitung t-stat, and (ADF-Fisher Chi-square). The results of the panel unit root tests are showed in Tables 1-6. Three test methods were calculated for 6 variables. These three methods were divided into 2 parts which is level and first difference.

For the Level way, the IPS test and MW-Fishe r ADF test are not at significance level (0.2529, 0.2725). Means that there are not rejected the null hypothesis and not significant for the CO_2 emission. It shows that CO_2 emission has the unit root and non-stationary at level. For Breitung test, that is <5% level of significance (0.0482). Means that it is rejected the null hypothesis and has significant. It shows that CO_2 emission has no unit root and stationary at level. For the first difference way the IPS test, MW-Fisher ADF, and Breitung test show that there are <5% level of significance (0.0162, 0.0218, 0.0147). Means that there are rejected the null hypothesis and have significant for the CO_2 emission. It shows that CO_2 emission has no unit root and stationary at first difference.

For the Level way, the IPS test, MW-Fisher ADF, and Breitung test are not at significance level (0.9388, 0.8839, 0.9315). Means that there are not rejected the null hypothesis and not significant for the consumption. It shows that Consumption has the unit root and non-stationary at Level. For the first difference way, the IPS test and Breitung test show that there are not at significance (0.1048, 0.9543). Means that there are not rejected the null hypothesis and not significant for the Consumption. It shows that Consumption has unit root and non-stationary at first difference. For MW-Fisher ADF, that is <5% level of significance (0.0334). Means that it is rejected the null hypothesis and has significant. It shows that Consumption has no unit root and stationary at first difference.

For the Level way, The IPS test, MW-Fisher ADF and Breitung test are not at significance level (0.8641, 0.6511, 0.9765). Means that there are not rejected the null hypothesis and not significant for the Forest. It shows that forest has the unit root and non-stationary at Level. For the First difference way, the IPS test and MW-Fisher

Table 1: Panel unit root tests for CO_2 emission

Unit root test	CO_2 emission (statistic)	Prob.*** (P-value)
Level		
IPS test	−0.66527	0.2529
MW-Fisher ADF	7.55602	0.2725
Breitung test	−1.66294	0.0482**
First difference		
IPS test	−2.13913	0.0162**
MW-Fisher ADF	14.8119	0.0218**
Breitung test	−2.17720	0.0147**

All unit root tests were performed with individual intercept and trends for each series. The optimal lag length was selected automatically using the Schwarz Info criterion. The null hypothesis is a unit root for all the tests. *Statistical significance at 10% level, **statistical significance at 5% level, ***statistical significance at 1% level. ADF: Augmented Dickey–Fuller, IPS: Im, Pesaran and shin

Table 2: Panel unit root tests for energy power consumption

Unit root test	Consumption (Statistic)	P***
Level		
IPS test	1.54482	0.9388
MW-Fisher ADF	2.35919	0.8839
Breitung test	1.48694	0.9315
First difference		
IPS test	−1.25473	0.1048
MW-Fisher ADF	13.6856	0.0334**
Breitung test	1.60132	0.9543

ADF: Augmented Dickey–Fuller, IPS: Im, Pesaran and shin

Table 3: Panel unit root tests for forest area

Unit root test	Forest area (statistic)	P***
Level		
IPS test	1.09871	0.8641
MW-Fisher ADF	4.18934	0.6511
Breitung test	1.98551	0.9765
First difference		
IPS test	0.50512	0.6933
MW-Fisher ADF	3.43413	0.7527
Breitung test	−1.32475	0.0926*

ADF: Augmented Dickey–Fuller, IPS: Im, Pesaran and shin

Table 4: Panel unit root tests for GDP growth

Unit root test	GDP growth (Statistic)	Prob.*** (P-value)
Level		
IPS test	−1.33658	0.0907*
MW-Fisher ADF	10.3690	0.1099
Breitung test	−2.91332	0.0018***
First difference		
IPS test	−4.26096	0.0000***
MW-Fisher ADF	26.7189	0.0002***
Breitung test	−2.51921	0.0059***

ADF: Augmented Dickey–Fuller, IPS: Im, Pesaran and shin, GDP: Gross domestic product

ADF show that there are not at significance level. Means that there are not rejected the null hypothesis and not significant for the forest. It shows that forest has unit root and non-stationary at first difference. For Breitung test, that is <10% level of significance. Means that it is rejected the null hypothesis and less significant. It shows that forest has no unit root and stationary at first difference.

For the level way, The IPS test and Breitung test have significance which is <10% and 1% level of significance (0.0907, 0.0018). Means that there are rejected the null hypothesis and have significant for the GDP. It shows that GDP has no unit root and stationary at Level. For MW-Fisher ADF, that is no at level of significance (0.1099). Means that it is not rejected the null hypothesis and not significant. It shows that GDP has unit root and non-stationary at level. For the First difference way, this 3 tests show that there are <1% level of significance (0.0000, 0.0002, 0.0059). Means that there are rejected the null hypothesis and have significant for the GDP. It shows that GDP has no unit root and stationary at first difference.

For the level way, The IPS test and MW-Fisher ADF test have significance which is <1% level of significance (0.0000). Means that there are rejected the null hypothesis and have significant for the Population. It shows that population has no unit root and stationary at level. For Breitung test, that is no at level of significance (0.6847). Means that it is not rejected the null hypothesis and not significant. It shows the population has unit root and non-stationary at level. For the First difference way, this 3 tests show that there are <1% level of significance (0.0000, 0.0000, 0.0057). Means that there are rejected the null hypothesis and have significant for the GDP. It shows that GDP has no unit root and stationary at first difference.

For the level way, this 3 tests show that there are not at level of significance (0.8044, 0.9127, 0.3403). Means that there are not rejected the null hypothesis and not significant for the Poverty. It shows that poverty has unit root and non-stationary at Level.

Table 5: Panel unit root tests for population

Unit root test	Population (statistic)	P***
Level		
IPS test	−11.8343	0.0000***
MW-Fisher ADF	54.8700	0.0000***
Breitung test	0.48099	0.6847
First difference		
IPS test	−12.1478	0.0000***
MW-Fisher ADF	45.0957	0.0000***
Breitung test	−2.52858	0.0057***

ADF: Augmented Dickey–Fuller, IPS: Im, Pesaran and shin

Table 6: Panel unit root tests for poverty

Unit root test	Poverty (statistic)	P***
Level		
IPS test	0.85762	0.8044
MW-Fisher ADF	2.07490	0.9127
Breitung test	−0.41162	0.3403
First difference		
IPS test	−2.08276	0.0186**
MW-Fisher ADF	15.1039	0.0195**
Breitung test	−3.74230	0.0001***

ADF: Augmented Dickey–Fuller, IPS: Im, Pesaran and Shin

For the First difference way, The IPS test and MW-Fisher ADF test have significance which is <5% level of significance (0.0186, 0.0195). Means that there are rejected the null hypothesis and have significant for the Poverty. It shows that poverty has no unit root and stationary at first difference. For Breitung test, that is <1% level of significance (0.0001). Means that it is rejected the null hypothesis and has strong significant. It shows that poverty has no unit root and stationary at first difference.

In conclusion, all three tests reject the joint null hypothesis for variables such as CO_2 emission (5%), GDP (1%), population (1%), and poverty (1% or 5%). Therefore, we can conclude that these variables have a panel unit root test. In contrast, all three tests are not rejected the joint null hypothesis for variables such as Consumption and Forest. Therefore, we can conclude that these variables have more than one panel unit root tests.

4.2 Panel Cointegration

Based on the Johansen Cointegrationtest for 6 variables such as CO_2 emission, consumption, Forest, GDP, population, and poverty, P-value for the null hypothesis of none cointegration equation is 0.000 where its value is <0.05%. So, the null hypothesis is rejected. For the null hypothesis at most 5 cointegrating equation exist, P-value more than 5% (0.0999 > 0.05). So, the null hypothesis is not rejected. Means that at least 4 cointegrating equation exists in the variables showed in Table 7.

4.3. Panel Granger Causality

Granger Causality test used to study the relationship between the dependent variable (CO_2 emission) and independent variables (consumption, GDP, forest, population, poverty) in Malaysia, Thailand, and Indonesia from 1991 to 2010 showed in Table 8. In addition, the test also used to study the relationship between each independent variable. The Granger Causality test shows 4 different situations. The first situation is x variable will influence y variable. The second situation is y variable will influence the X

Table 7: Johansen cointegration test

Unrestricted cointegration rank test (trace and maximum eigenvalue)				
Hypothesized Number of CE (s)	Fisher statics* (from trace test)	P	Fisher statics* (from max-Eigen test)	P
None	38.23	0.0000	38.23	0.0000
At most 1	158.4	0.0000	103.5	0.0000
At most 2	98.29	0.0000	60.59	0.0000
At most 3	52.09	0.0000	30.41	0.0000
At most 4	31.47	0.0000	30.15	0.0000
At most 5	10.65	0.0999	10.65	0.0999

*Probabilities are computed using. Asymptotic Chi-square distribution

Table 8: Granger causality test

Null hypothesis	Obs	F-statistic	P
CONSUMPTION does not Granger Cause CO_2	54	0.23182	0.7940
CO_2 does not Granger Cause CONSUMPTION		0.79696	0.4565
FOREST does not Granger Cause CO_2	54	0.49338	0.6136
CO_2 does not Granger Cause FOREST		0.78054	0.4638
GDP does not Granger Cause CO_2	54	2.33318	0.1077
CO_2 does not Granger Cause GDP		0.57942	0.5640
POPULATION does not Granger Cause CO_2	54	1.12506	0.3329
CO_2 does not Granger Cause POPULATION		1.67504	0.1978
POVERTY does not Granger Cause CO_2	54	0.42276	0.6576
CO_2 does not Granger Cause POVERTY		0.98188	0.3819
FOREST does not Granger Cause CONSUMPTION	54	0.35851	0.7005
CONSUMPTION does not Granger Cause FOREST		0.68433	0.5092
GDP does not Granger Cause CONSUMPTION	54	0.35332	0.7041
CONSUMPTION does not Granger Cause GDP		0.46595	0.6303
POPULATION does not Granger Cause CONSUMPTION	54	0.38915	0.6797
CONSUMPTION does not Granger Cause POPULATION		1.54667	0.2232
POVERTY does not Granger Cause CONSUMPTION	54	0.72205	0.4909
CONSUMPTION does not Granger Cause POVERTY		0.99382	0.3775
GDP does not Granger Cause FOREST	54	0.39664	0.6747
FOREST does not Granger Cause GDP		0.32005	0.7276
POPULATION does not Granger Cause FOREST	54	1.64525	0.2034
FOREST does not Granger Cause POPULATION		1.23991	0.2983
POVERTY does not Granger Cause FOREST	54	4.19387	0.0208
FOREST does not Granger Cause POVERTY		1.48907	0.2356
POPULATION does not Granger Cause GDP	54	0.35609	0.7022
GDP does not Granger Cause POPULATION		0.55294	0.5788
POVERTY does not Granger Cause GDP	54	1.88990	0.1619
GDP does not Granger Cause POVERTY		0.02722	0.9732
POVERTY does not Granger Cause POPULATION	54	2.05372	0.1392
POPULATION does not Granger Cause POVERTY		1.04911	0.3580

GDP: Gross domestic product

variable. The third situation is x and y variable can be influenced by each other. The last situation is the variable of x and y does not influence each other. Following the Granger Causality test result, null hypothesis will be rejected if the P-value is <5% and has significance. Thus, the null hypothesis rejected which the data shows Poverty does not granger cause Forest (0.0208).

For other result, the null hypothesis is not rejected such as Consumption does not granger cause CO_2, CO_2 does not granger cause consumption, poverty does not granger cause CO_2, and CO_2 does not granger cause Poverty. For the relationship between each independent variable result, it shows no significance because the P-value is more than 5% and the variables is independently such as GDP does not granger cause Consumption, Consumption does not granger cause GDP, Population does not granger cause Forest, and Forest does not granger cause Population.

5. CONCLUSION

The objective of the study is to determine the relationship between carbon dioxide emission, EC, economic growth, population, poverty rate and forest area of three ASEAN countries namely Indonesia, Malaysia, and Thailand. The study used annual time series data over 20 years from 1991 to 2010. Based on finding of the study, panel unit root of all variables were stationary. For the stability of the model, the model is found that it is stable. From Johansen Cointegration test, it showed that there are at least two co-integrating equations in the study, while Granger Causality test only showed that there is a unidirectional causality from carbon dioxide (CO_2) emission to forest area.

To summurise, each variable will influence the changes of carbon dioxide emission when changes the EC, economic growth, population, poverty and forest area in Malaysia, Thailand and

Indonesia. That is positive relationship between carbon dioxide emission with consumption, economic growth and population. In contrast, that is negative relationship between carbon dioxide emission with forest and poverty.

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