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# Trade Openness and Environmental Degradation in Asean-5 Countries

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## Abstract

This study investigates the relationship between trade openness and carbon dioxide (CO<sub>2</sub>) emissions among ASEAN-5 countries (Indonesia, Malaysia, Philippines, Singapore, and Thailand) during the period from 1995 to 2014. The variables used are trade openness, carbon dioxide emissions, gross domestic product, energy consumption, and foreign direct investment. Methodologies applied in this study are Panel Unit Root test, Pedroni Co-integration test, and Panel Granger Causality. The results of this study show there is a long-run relationship between the variables in ASEAN-5 countries. The results further show there is a bidirectional causal relationship between carbon dioxide, economic growth, and energy consumption in the short-run. The results of this study imply that ASEAN policy makers should focus on the implementation of carbon tariff and promote the energy efficiency usage.

**Keywords:** Environmental Degradation, Trade Openness, Cointegration, Granger Causality.

## Introduction

Trade openness enables domestic industrial sector of a country to expand more rapidly as compared to a closed economy. Economic growth can be accelerated by trade openness with the agreement of trade among countries (Sulaiman & Abdul-Rahim, 2017). There are number of agreements on international trade among the countries about tariffs, imports and exports such as General Agreement on Tariffs and Trade (GATT) and World Trade Organisation (WTO). A bilateral and multilateral Free Trade Agreement (FTA) among countries can minimize the trade barrier in their economic relationship. Trade liberalization is good for economy in terms of prices, investments, productivities and so on. On contrary, trade openness causes policy of aggressive market entry, intricacy of the system of international trading, and structural unemployment (Drozd & Miskinis, 2011).

Emphasizing on the gains from trade towards the environmental quality is referred as the hypothesis of gain-from-trade while race-to-the-bottom hypothesis is referred for the nation's racing to the bottom of environmental quality in aiming for the development of trade-led (Ibrahim & Rizvi, 2015).

Furthermore, based on Managi (2004), there will be both positive and negative impacts on the environment when trade openness occurred internationally. The effects of scale, technique, and composition are the three pieces of impacts that can be decomposed. When there is a development on trade-led, an increasing of income can be seen. It is because trade involves import and export that need the calculation of exchange rates for the price and so on. After raising the income, the people or public start to demand a cleaner environment for living. In addition, the technology of the production that has the concept of environmentally friendly are vastly used especially in a developed country. Therefore, some of the industries that practices an environmentally unfriendly production are shifting their plan from a developed country to any developing countries. A richer country advocates a strict environmental regulation in order to produce a greener goods and services that do not harm the environment.

Pollution haven hypothesis (PHH) which under the free trade usually assert that the poor or developing countries may customize in the productions or sectors of pollution intensive as of their comparative advantages (Loi, 2010). Multinational firms normally opted to shift their environmentally harmful production to any of the least developed countries (LDC) or developing countries due to its lax of environmental regulation and monitoring activities (Ibrahim & Rizvi, 2015). Environmental degradation are the common issues for any countries that practices open economy. Study by Oktavilia and Firmansyah (2016) shows that trade openness in Indonesia has not only improve their international trade and foreign demand, but also increase the CO<sub>2</sub> emission of the country between the year 1976 to 2014.

Environmental issues are reported in global especially the air and water pollution which are becoming the most concern to human being. The natural ecosystems and the health of living beings are affected by air pollution (Sepideh, 2015). Globalization worsen the environmental problems faced globally. The reallocation of environmentally unfriendly industrial activities to any of the LDC and developing countries has encouraged deforestation. With the production in place and no proper monitoring form the government, more CO<sub>2</sub> will be emitted to the atmosphere.

These leads to more carbon dioxide are released to the atmosphere. Carbon dioxide emissions become greenhouse gas (GHG) that is harmful to human being. GHG keeps increasing due to the activities of globalization and industrialization. According to World Trade Organization (2010), annual world carbon dioxide (CO<sub>2</sub>) emissions from combustion of fuel rise from 14.1 billion tonnes to 28.9 billion tonnes from 1971 – 2007.

According to Prasad and Asafu-Adjaye (2003), the positive link between the trade openness and environmental degradation require a distinct and proper agreement between the trading countries. In addition, the international trade especially in trade of agriculture will have the impacts on the quality of environment in ASEAN members' countries and its partners of trade when the flow of the agriculture trade increase (Atici, 2011). Indonesia has been dealing with "carbon sinks" environment since the economic liberalization took place in mid 1980s due to human activities and deforestation (Ubaidillah et al., 2013).

According to Neil (1998), regime switch in Thailand has encourages an economic shift of the country onto an export-oriented industrializing economy. Thus, during the 11th National Economic and Social

Development Plan, the government of Thailand emphasises on the environmental issues. Philippines also applied the trade liberalization in order to improve their economy. A total of three phases of trade reform programme are introduced by the government of the Philippines. Unfortunately, improvement in the economy of Philippines increases the GHG emissions in the country.

According to United State Agency for International Development, USAID (2016), together with a 4% growth in the economy, the GHG emissions of Philippines went up to 53%, which with an average of 2.1% yearly from the year of 1990 to 2012. In the context of Singapore, the government has formed an Anti-Pollution Unit in 1970 to regulate the industries by rejecting any economic activities which caused pollution in Singapore (Sam, 2016).

This paper aims to examine the nexus between carbon dioxide emissions, trade openness, economic growth (GDP), energy consumption, and foreign direct investment (FDI) for ASEAN-5 countries. The following sections presents the review of past studies follows by the methodology section. Next, results and discussion are presented in the subsequent section and last but not least, the conclusion section will also offer the policy implications of this study.

### **Literature Review**

Trade openness is playing a significant role in improving the performance of global economic and at the same time causing serious environmental issues including the excessive emission of carbon dioxide. According to Grossman and Krueger, the negative relationship between trade openness and environment degradation noted its resemblance to Environmental Kuznets Curve (EKC) that shows an inverted-U relationship between environmental degradation and economic growth in 1993 (Dasgupta, Laplante, Wang, & Wheeler, 2002; Perman & Stern, 2003; Stern, 2003). Studies such as Nahman and Antrobus (2005) found the evidence of EKC in the case of North American Free Trade Agreement (NAFTA) region.

The inverted-U shaped of EKC usually are explained is two different stages. The first stage where the income per capita and environmental degradation of a country increases thought out the period of time. The turning point of the curve started when the economy is at its peak where there is more discretionary income therefore enable the economic players to pay a higher price in return for a better environmental standard. For the downward sloping of the EKC, there are some debates about the sloping that it is an illusion causing from the movement of polluting industries for relocation (Perman & Stern, 2003).

Several studies offer support to the relationship between trade openness and emissions of carbon dioxide (Gu, Gao, & Li, 2013; Ibrahim & Rizvi, 2015; Sulaiman & Abdul-Rahim, 2017). Gu et al. (2013) shows that there is an existence of unidirectional causality from foreign trade dependency to carbon dioxide emissions. On this note, Vidyarthi (2014) supported the relationship between the energy consumption, economic growth, and carbon dioxide emissions. Other studies such as Rahman (2013) and Oktavilia and Firmansyah (2016) found trade openness fosters the growth of carbon dioxide emissions. This contention is also supported by a stream of studies such as Sepideh (2015); Ayeche, Barhoumi and Hammas (2016); Bernard and Mandal (2016) and Keho (2016). Nevertheless, Akin

(2014) claimed carbon dioxide emissions can be reduced by trade openness and there is unidirectional causality from carbon dioxide emissions to trade openness.

Free trade fosters the emissions and decrease the quality of environment (Managi, 2004); McCarney & Adamowicz, 2016). Hakimi and Hamdi (2016) added the negative impact to environment in Morocco and Tunisia is caused by trade openness. In the same vein, there is a long-run relationship between the economic growth and carbon dioxide emissions (Sam, 2016; Salahuddin, Gow, & Ozturk, 2015; Nasreen & Anwar, 2015) and the relationship could be a bidirectional causality (Adom, Bekoe, Amuakwa-Mensah, Mensah, & Botchway, 2012; Salahuddin, et al. 2015) as well as unidirectional causality from carbon dioxide emissions to economic growth (Bekhet & Yaasmin, 2013; Chen & Huang, 2013). Tan, Lean, and Khan (2014) suggested that the carbon dioxide emissions increased when there is a rise in GDP over years. According to Opoku, Amoako, and Amankwa (2014), the empirical results found that real GDP per capita has the positive impacts on the emissions of carbon dioxide while real GDP per capita squared has the negative impacts on the carbon dioxide emission in the long run.

In another stream of studies, there is a short-run causality from the energy consumption to the emissions of carbon dioxide (Hossain, 2012; Vidyarthi, 2013; Farhani, Chaibi, & Rault, 2014). Furthermore, the empirical results show a presence of unidirectional causality from the energy consumption to the carbon dioxide emissions (Kiviyiro & Arminen, 2014; Mohapatra & Giri, 2015). Vidyarthi (2014) showed the long-run relationship between the economic growth, energy consumption and the emissions of carbon dioxide. Behera and Dash (2017) show that there is a cointegrating relationship between foreign direct investment, fossil fuel energy consumption, and carbon dioxide emissions too. Nevertheless, Zhang and Zhou (2016) show foreign direct investment hampers the carbon dioxide emissions in China.

### Methodology

This study focuses on ASEAN-5 countries namely Indonesia, Malaysia, Philippines, Singapore, and Thailand over the study period of 1995 to 2014. A set of variables used in the model are carbon dioxide emissions (CO<sub>2</sub>), trade openness, gross domestic product (GDP), energy consumption, and foreign direct investment (FDI) and the data is extracted from World Bank database. The CO<sub>2</sub> emissions (metric tons per capita), trade (% of GDP), GDP per capita (constant 2010 US\$), energy use (kg of oil equivalent per capita), and foreign direct investment, net inflow (% of GDP) are obtained from World Bank's World Development Indicators (WDI).

The relationship between CO<sub>2</sub> emissions, trade openness, economic growth, energy consumption, and foreign direct investment can be expressed as following:

$$CO_2 = \beta_0 + \beta_1 TO_{it} + \beta_2 GDP_{it} + \beta_3 EC_{it} + \beta_4 FDI_{it} + \varepsilon_{it} \quad (1)$$

where  $i$  represents country (Indonesia, Malaysia, Philippines, Singapore, and Thailand);  $t$  represents time (1995, ..., 2014.); CO<sub>2</sub> represents carbon dioxide emissions (metric tons per capita); TO represents trade (% of GDP); GDP represents the gross domestic product (GDP) per capita (constant 2010 US\$); EC represents energy use (kg of oil equivalent per capita); FDI represents foreign direct

investment, net inflow (% of GDP); foreign direct investment (FDI) and  $\varepsilon$  represents the error term. The empirical model of this study is adopted from Ibrahim and Rizvi (2015).

### *Pedroni (Engle-Granger based) Co-integration Test*

Pedroni test is applied to investigate the long-run relationship between variables if the panel unit root exists in variables. According to Ramirez (2006), Pedroni test is employed to determine the existence of co-integrating relationship. There are seven tests that proposed by Pedroni, which there will be comparison between the maximum-likelihood-based panel co-integration statistics and the two within-dimension-based and two between-dimension-based panel co-integration statistics. The tests are panel  $\nu$ -statistic, panel rho-statistic, panel PP-statistic, panel ADF-statistic, group rho-statistic, group PP-statistic, and group ADF-statistic. The regression is considered as below:

$$y_{it} = \alpha_i + \delta_i t + \beta_{1i} x_{1i,t} + \beta_{2i} x_{2i,t} + \dots + \beta_{Mi} x_{Mi,t} + \varepsilon_{i,t} \quad (1)$$

where  $t = 1, \dots, T$ ;  $i = 1, \dots, N$ ;  $m = 1, \dots, M$ ;  $y$  and  $x$  are assumed to be integrated of order one like  $I(1)$ . The parameters of  $\alpha_i$  and  $\delta_i$  are individual and trend effects, which may be set to zero if desired,  $M$  is the number of regressors,  $t$  is the number of observations, and  $\beta_1, \beta_2,$  and  $\beta_k$  are coefficients of slope. The residual,  $\varepsilon_{i,t}$ , will be  $I(1)$  when under the no co-integration from null hypothesis. In order to have the residuals and test on entailing the  $I(1)$ , by running auxiliary regression.

$$\varepsilon_{i,t} = \rho_i \varepsilon_{i,t-1} + u_{i,t} \quad (2)$$

The null hypothesis of no co-integration for the panel co-integration test is as below.

$$H_0; \gamma_i = 1 \text{ for all } i = 1, \dots, N \quad (3)$$

Based on Pedroni (1999), there are consisting of two types of  $H_a$ , which are for between-dimension-based and within-dimension-based. The alternative hypothesis for the between-dimension-based is:

$$H_a; \gamma_i < 1 \text{ for all } i = 1, \dots, N \quad (4)$$

where there is not required for a common value for  $\gamma_i = \gamma$ , as this heterogeneous alternative also referred to group statistics test. For the within-dimension-based, alternative hypothesis is:

$$H_a; (\gamma_i = \gamma) < 1 \text{ for all } i = 1, \dots, N \quad (5)$$

where there is a common value for  $\gamma_i = \gamma$ , as this homogenous alternative also referred as panel statistics test. After the calculation for appropriate mean and variance adjustment terms to each of the panel test statistics, the approximate asymptotic distributions are conducted and then compute the approximate critical values for each tests. The asymptotic normal distributed standardized statistics is shown as below:

$$\frac{\aleph_{N,T} - \mu\sqrt{N}}{\sqrt{\nu}} \Rightarrow N(0, 1) \quad (6)$$

where  $\aleph_{N,T}$  is the appropriately standardized with respect to the dimensions of  $N$  and  $T$ ;  $\mu$  and  $\nu$  are functions of moments of the underlying Brownian motion functional.

### *Panel Granger Causality Test*

The Granger Causality is computed by running bivariate regressions. In general, the bivariate regressions in a panel data context take the form:

$$y_{i,t} = \alpha_{0,i} + \alpha_{1,i}y_{i,t-1} + \dots + \alpha_{k,i}y_{i,t-k} + \beta_{1,i}x_{i,t-1} + \dots + \beta_{k,i}x_{i,t-k} + \varepsilon_{i,t} \quad (7)$$

$$x_{i,t} = \alpha_{0,i} + \alpha_{1,i}x_{i,t-1} + \dots + \alpha_{k,i}x_{i,t-k} + \beta_{1,i}y_{i,t-1} + \dots + \beta_{k,i}y_{i,t-k} + \varepsilon_{i,t} \quad (8)$$

where  $t$  indicates the time period dimension of the panel, while  $i$  indicates the cross-sectional dimension.

There are two approaches used to test the panel granger causality, which are Stacked test (common coefficients) and Dumitrescu Hurlin (individual coefficients). The approach of individual coefficients which adopted by Dumutrescu Hurli:

$$\alpha_{0,i} \neq \alpha_{0,j}, \alpha_{1,i} \neq \alpha_{1,j}, \dots, \alpha_{k,i} \neq \alpha_{k,j}, \forall i, j \quad (9)$$

$$\beta_{0,i} \neq \beta_{0,j}, \dots, \beta_{k,i} \neq \beta_{k,j}, \forall i, j \quad (10)$$

Simply running standard Granger Causality regressions calculates the Dumitrescu Hurlin test, which is for each cross-section individually. Wbar statistic is the term for the average of the test statistics, while Zbar statistics is the term for the standardized version of statistic, appropriately weighted in the unbalanced panels, and a standard normal distribution is followed. The null hypothesis for the Panel Granger Causality, which shows the absence of Granger Causality is as below:

$$H_0 : \forall k \geq 1 \text{ and } \forall i, \beta_{i,k} = 0 ; x_{i,t} \text{ does not granger cause } y_{i,t}, \forall I \quad (11)$$

The alternative hypothesis for Panel Granger Causality, which has the presence of Granger Causality, is shown as below:

$$H_A : \forall k \geq 1 \text{ and } \forall i, \beta_{i,k} \neq 0 ; x_{i,t} \text{ does not granger cause } y_{i,t}, \forall I \quad (12)$$

**Empirical Results***Descriptive Statistics*

Table 1: Descriptive Statistics of the Variables

	<b>LCO2</b>	<b>LTO</b>	<b>LGDP</b>	<b>LEC</b>	<b>LFDI</b>
<b>MEAN</b>	0.496150	2.113910	3.758702	3.158450	0.779446
<b>MEDIAN</b>	0.575393	2.094256	3.629717	3.175294	0.764984
<b>MAXIMUM</b>	1.187305	2.645033	4.714880	3.867506	1.724778
<b>MINIMUM</b>	-0.112998	1.630889	3.177993	2.617082	-0.729649
<b>STD. DEV.</b>	0.393575	0.294358	0.472254	0.372271	0.487734
<b>SKEWNESS</b>	-0.087036	0.238439	0.782570	0.179481	-0.250141
<b>KURTOSIS</b>	1.652993	1.969441	2.361395	1.792289	3.681393

Note: Std. Dev. denotes standard deviation. LCO2 indicates log of carbon dioxide emissions. LTO indicates log of trade openness. LGDP indicates log of gross domestic product. LEC indicates log of energy consumption. LFDI indicates log of foreign direct investment.

Based on Table 1, it is clearly seen that all of the variables have the positive skewness except carbon dioxide emissions (LCO2) and foreign direct investment (LFDI). However, overall, the variables have positive skewness of the statistics, which mean that the distribution is skewed to the right and hence has the long right tail. Besides that, according to the results in Table 1, it is observed that only kurtosis of foreign direct investment (LFDI) exceed 3. It can be indicated that the distribution of foreign direct investment (LFDI) is peaked relative to normal. While for the distribution of trade openness (LTO), carbon dioxide emissions (LCO2), gross domestic product (LGDP), and energy consumption (LEC) are flat relative to normal. Therefore, the variables are not normally distributed.

Table 2: Correlation, the Multivariate Descriptive Statistics

	<b>LCO2</b>	<b>LTO</b>	<b>LGDP</b>	<b>LEC</b>	<b>LFDI</b>
<b>LCO2</b>	1.000000	0.825626	0.893102	0.965740	0.699574
<b>LTO</b>	0.825626	1.000000	0.892998	0.883380	0.764215
<b>LGDP</b>	0.893102	0.892998	1.000000	0.958887	0.803055
<b>LEC</b>	0.965740	0.883380	0.958887	1.000000	0.747672
<b>LFDI</b>	0.699574	0.764215	0.803055	0.747672	1.000000

Note: LCO2 indicates log of carbon dioxide emissions. LTO indicates log of trade openness. LGDP indicates log of gross domestic product. LEC indicates log of energy consumption. LFDI indicates log of foreign direct investment.

Based on Table 2, all of the variables are showing the positive correlation, which are from +1.0 to 0. All of the variables are above +0.6 and less than +1.0. There are positive relationships between all the variables such as between carbon dioxide emissions (LCO2) and trade openness (LTO), and between trade openness (LTO) and energy consumption (LEC). For one of the relationships between the variables, which are LCO2 and LTO, it shows that when trade openness increases, the carbon dioxide emissions increase too.

Panel Unit Root Test

Panel Unit Root Tests of LLC and IPS for each variable are conducted as a preliminary analysis. The results of these tests are reported in Table 3 and Table 4.

Table 3: Panel Unit Root Test Results (Levin, Lin & Chu t)

	LEVEL		FIRST DIFFERENCE	
	$\mu$	$\tau$	$\mu$	$\tau$
<b>LCO2</b>	0.31544 (0.6238)	-1.61025 (0.0537)	-5.63351** (0.0000)	-4.93080** (0.0000)
<b>LTO</b>	-0.54149 (0.2941)	-2.31469** (0.0103)	-4.57450** (0.0000)	-3.75169** (0.0001)
<b>LGDP</b>	3.08042 (0.9990)	-4.02210** (0.0000)	-5.45313** (0.0000)	-6.64940** (0.0000)
<b>LEC</b>	-0.27060 (0.3934)	-1.06888 (0.1426)	-5.50941** (0.0000)	-4.12476** (0.0000)
<b>LFDI</b>	-2.38643** (0.0085)	-3.04837** (0.0012)	-4.27974** (0.0000)	-2.88903** (0.0019)

Note: \*\* denotes the significant at 5 percent level. The  $\mu$  in the model allows a drift term. The  $\tau$  in the model allows a drift and deterministic trend.

Table 4: Panel Unit Root Test Results (Im, Pesaran and Shin W-stat)

	LEVEL		FIRST DIFFERENCE	
	$\mu$	$\tau$	$\mu$	$\tau$
<b>LCO2</b>	1.43462 (0.9243)	-0.77895 (0.2180)	-5.02281** (0.0000)	-4.14161** (0.0000)
<b>LTO</b>	0.46793 (0.6801)	-0.70337 (0.2409)	-4.79074** (0.0000)	-4.22624** (0.0000)
<b>LGDP</b>	4.91659 (1.0000)	-1.80359** (0.0356)	-4.49075** (0.0000)	-5.32118** (0.0000)
<b>LEC</b>	1.12152 (0.8690)	-0.35569 (0.3610)	-5.06367** (0.0000)	-3.51922** (0.0002)
<b>LFDI</b>	-3.33229** (0.0004)	-3.03589** (0.0012)	-6.15673** (0.0000)	-4.81662** (0.0000)

Note: \*\* denotes the significant at 5 percent level. The  $\mu$  in the model allows a drift term. The  $\tau$  in the model allows a drift and deterministic trend.

Table 3 and Table 4 show the results of Panel Unit Root Tests. At level of LLC, trade openness (LTO), gross domestic product (LGDP), and foreign direct investment (LFDI) reject null hypothesis and significant at 5 percent level. This indicates these three variables are stationary at level. While there are two variables, which are carbon dioxide emissions (LCO2) and energy consumption (LEC), do not reject the null hypothesis at level of LLC. This shows the variables are not stationary at level, either allowing drift term or allowing the drift and deterministic term. Hence, LCO2 and LEC are tested at

first difference. The results show these variables reject the null hypothesis and hence indicate LCO2 and LEC are stationary at first difference.

For IPS, the results for the stationarities are difference from LLC. At level, the null hypothesis of IPS is rejected by gross domestic product (LGDP) and foreign direct investment (LFDI), which show the variables are stationary at level. However, the variables of carbon dioxide emissions (LCO2), trade openness (LTO), and energy consumption (LEC) are not stationary at level. So, LCO2, LTO, and LEC need to proceed to first difference of the Panel Unit Root to test for the stationarities. The results show the rejection of null hypothesis and are stationary at first difference. The unit root results show the variables are stationary at I(0) and I(1).

#### *Pedroni (Engle-Granger based) Co-integration Test*

Since there are stationarities on the Panel Unit Root, Panel Co-integration Test is proceeded. The result is shown in Table 5. For individual intercept as well as individual intercept and individual trend, both of these share the same results that of 4 out of 7 test statistic are significant at level of 5 percent. With the results, it shows that the variables are co-integrated. There is the existence of a long-run relationship between carbon dioxide emissions, trade openness, gross domestic product, energy consumption, and foreign direct investment. There is a long-run relationship between variables in the study of the impact of energy consumption, economic growth, and trade openness on carbon dioxide emissions (Akin, 2014). The results also show there are at least in one direction for the causality.

Table 5: Pedroni (Engle-Granger based) Co-integration Test Results

	PANELS	INDIVIDUAL INTERCEPT	INDIVIDUAL INTERCEPT AND INDIVIDUAL TREND
<b>WITHIN-DIMENSION</b>	Panel v-Statistic	-1.002849 (0.8420)	-2.187165 (0.9856)
	Panel rho-Statistic	0.997197 (0.8407)	1.766240 (0.9613)
	Panel PP-Statistic	-9.311520** (0.0000)	-9.569180** (0.0000)
	Panel ADF-Statistic	-4.187867** (0.0000)	-3.953265** (0.0000)
<b>BETWEEN-DIMENSION</b>	Group rho-Statistic	2.006804 (0.9776)	2.502416 (0.9938)
	Group PP-Statistic	-5.351129** (0.0000)	-5.585479** (0.0000)
	Group ADF-Statistic	-2.867075** (0.0021)	-2.675949** (0.0037)

Note: \*\* denotes the significant at 5 percent level

Panel Granger Causality Test

Panel Granger Causality Test is used in this study. All variables are treated endogenously by Panel Granger Causality. This indicates that there is an opportunity for each of the variables to become the dependent variable. Panel Granger Causality applied to indicate the direction of causality among these variables. Results of Panel Granger Causality are shown in Table 6.

Table 6: Panel Granger Causality Test Results

VARIABLES	$\Delta\text{LCO2}$	$\Delta\text{LTO}$	$\Delta\text{LGDP}$	$\Delta\text{LEC}$	$\Delta\text{LFDI}$
$\Delta\text{LCO2}$	-	6.14028** (0.0030)	3.34210 (0.4412)	4.55723 (0.0842)	1.17586 (0.3498)
$\Delta\text{LTO}$	5.54272** (0.0123)	-	10.0127** (2.E-09)	7.20541** (0.0001)	0.86939 (0.2395)
$\Delta\text{LGDP}$	5.30210** (0.0207)	5.21671** (0.0247)	-	6.40544** (0.0015)	3.69138 (0.2960)
$\Delta\text{LEC}$	1.46927 (0.4814)	5.26163** (0.0225)	4.37373 (0.1136)	-	1.26932 (0.3890)
$\Delta\text{LFDI}$	3.18013 (0.5204)	2.27852 (0.9466)	3.72913 (0.2824)	4.41850 (0.1058)	-

Note: \*\*

denotes significant at 5 percent level. ( ) indicates the p-value

Based on the results of the Panel Granger Causality, there are bidirectional and unidirectional short-run relationship between the variables. This shows a unidirectional causality in the short-run from LCO2 to LGDP. . In the short-run, carbon dioxide emissions cause or affects the gross domestic product and the gross domestic product affects the energy consumption. The unidirectional causal relationship existed from carbon dioxide emissions to gross domestic product (Chen and Huang, 2013), In addition, based on Hossain (2012) and Chandran and Tang (2013), there is a unidirectional causality relationship from carbon dioxide emissions to economic growth. Existence of unidirectional causality from carbon dioxide emissions to gross domestic product implies that the economic growth is promoted when there are higher carbon dioxide emissions (Vidyarthi, 2014). The industrialization and globalization activities are the major contributor of environment degradation. The manufacturing process of producing goods and services that generates the economy normally are the main emitters of unwanted gas especially carbon dioxide in any country. In addition, a unidirectional causality also shows in the results, which from LGDP to LEC. When economic growth is presence, it causes the consumption of energy. When there has the growth of economic in ASEAN-5, energy is consumed for exports, imports, and even production. Based on Vidyarthi (2013), in the short-run, the finding shows there is a unidirectional causality from gross domestic product to energy consumption. This short-run relationship indicates that the rise in the gross domestic product, which makes the economic to growth thus , intensify the energy consumption. The higher the gross domestic product among ASEAN-5 countries, the more the consumption of energy.

Besides that, there are existing of bidirectional causality in the short-run of the study, which are LCO2 and trade openness (LTO), LTO and LGDP, and LTO and LEC. Two-way causal relationship between LCO2 and LTO shows both of these are affecting each other. Similar to the relationship between LTO and LGDP, and LTO and LEC. According to Akin (2014) and Hakimi and Hamdi (2016), in their study, there is a bidirectional causality

between gross domestic product and trade openness. High in trade openness is showing the acceleration of production in some industries. Then, the industrialization due to the trading causes the carbon dioxide emissions. In line with the finding from Ayeche, Barhoumi, and Hammas (2016), the positive relationship between trade openness and carbon dioxide emissions is also apparent in the case of ASEAN-5 countries. With the acceleration of industrialization and trading activities, the emission of carbon dioxide from the industries will also increase throughout the economic development.

As there is a bidirectional causality relationship between trade openness and carbon dioxide emission, any increment in the carbon dioxide emission is expected to improve the wellbeing of the economy thru trade openness and vice versa (Vidyarthi, 2014).

### *Discussion of the Results*

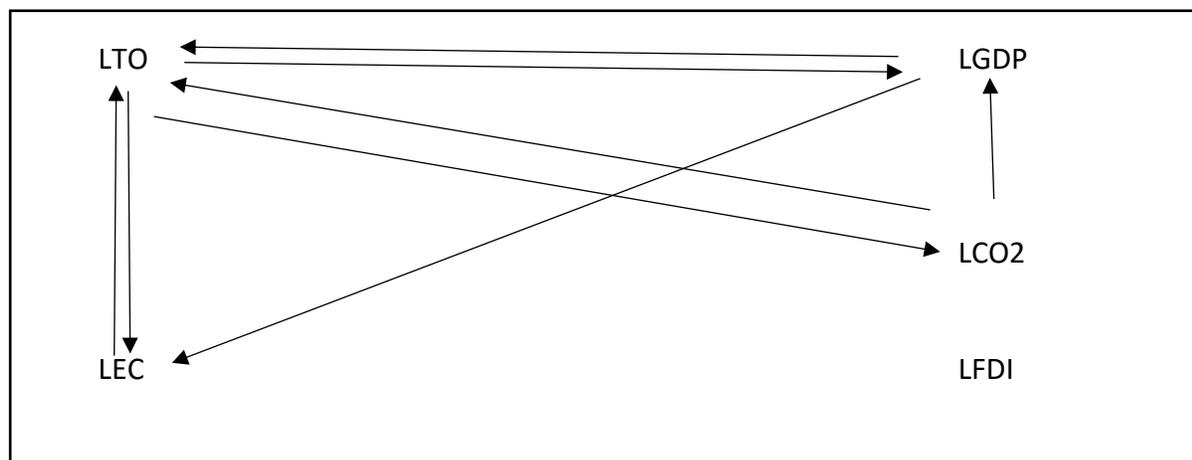


Figure 1: Short-run Causality Direction

Based on the figure, there are three direct bidirectional causality relationship, which are between LCO2 and LTO, LTO and LGDP, and LTO and LEC, and two direct unidirectional causality relationship, which are from LCO2 to LGDP, and from LGDP to LEC. The result also shows there are exist of indirect causal relationship among the variables. LTO indirectly causes LEC through LGDP. It is also indirectly caused by LCO2 through LGDP. In addition, there is an indirection causal relationship from LCO2 to LGDP through LTO. Growth of economic in ASEAN-5 countries can promote the trade openness. Due to trading activities among countries, there is exerting of the energy consumption for productions. Carbon dioxide emissions cause the trade openness indirectly. From the results of this study, the emissions of carbon dioxide promote economic growth as more factories are built for productions in order to improve the gross domestic production. Trading among the countries in ASEAN-5 is facilitated by economic growth. In short-run, carbon dioxide emissions also cause gross domestic product indirectly. Trade openness is improved by emissions of carbon dioxide. Then, rise of the trade openness contributes to the economic growth, which improve the gross domestic product. Moreover, LGDP causes the LEC indirectly through LTO. Energy consumption can be enhanced indirectly by trade openness as when trade openness is occurred, economic growth in ASEAN-5 will improve. This will lead to the push towards for the consumption of energy.

Nevertheless, foreign direct investment (LFDI) shows no short causal relationship between trade openness and carbon dioxide emissions in the short-run. It indicates that FDI does not affect and affected by the trade openness, carbon dioxide emissions or the environmental degradation, economic growth and energy consumption in ASEAN-5. There is also no short-run relationship between foreign direct investment and economic growth as well as the energy consumption. According to the findings of Shaari, Hussain, Abdullah, and Kamil (2014), there is no evidence of the granger causality relationship between the foreign direct investment and carbon dioxide emissions, and between the gross domestic product and foreign direct investment. In addition, the foreign direct investment and energy consumption do not have the causal relationship as well. This result is as same as the finding from Ojewumi and Posu (2016), which the results of no existence of short-run causality relationship between foreign direct investment and energy consumption.

In other words, trade openness and carbon dioxide emissions do have relationships in the long-run and bidirectional causal relationship in short-run among ASEAN-5 countries. Trade openness and carbon dioxide emissions are positively related among ASEAN-5 countries. In short-run, trade openness also shows an indirect relationship with carbon dioxide emissions. From the results, there are the determinants, which is gross domestic product, on the nexus between trade openness and carbon dioxide emissions in ASEAN-5. The economic growth is affected by carbon dioxide emissions, which is the environmental degradation and causes the trade openness in the short-run. When there is a rise in the emissions of carbon dioxide due to the increase of industries that emit the carbon dioxide, the gross domestic product will increase and leads to growth of economic. For the determinant of energy consumption, it does not have the relationship between trade openness and carbon dioxide emissions, but it does have a relationship between the trade openness and energy growth in ASEAN-5 for short-run.

### **Conclusion**

This study emphasizes on the relationship between trade openness and carbon dioxide emissions among ASEAN-5 countries. The findings and the research framework have their difference, which is the variable of foreign direct investment (FDI), in the short-run. FDI does not affect the emissions of carbon dioxide and other variables such as trade openness, gross domestic product, and energy consumption in the short-run causal relationship. Trade openness and carbon dioxide emissions do have a positive relationship among ASEAN-5 countries. From the findings, in the short-run, it shows that trade openness affects carbon dioxide emissions, economic growth, and energy consumption. Besides, the results show that carbon dioxide emissions, trade openness, gross domestic product, energy consumption, and foreign direct investment have a long-run relationship among ASEAN-5 countries.

The rapid development of economic integration between countries has created various new fields of discussion with regards to the sustainability of the economic, social and environment. Recently, the government is taking into consideration the environmental aspects prior to any business or trade decision for the country. Priority is given to the economic activates that yield the maximum economic and social benefit and at the same time have the least impact on the environment. Balancing between economic profit and environmental sustainability is not an easy task for developing ASEAN-5

countries. Estimating the relationship between the economy and trade liberalization with the environmental degradation of the home countries will offer a bigger picture of the importance of environment toward economic sustainability.

Developing ASEAN-5 countries surely have various room for improvement especially in term of their environmental policies Under ASEAN Centre for Energy, some plans have been implemented including energy efficiency and conservation. ASEAN-5 countries have implemented the policies for energy efficiency such as the reduction of energy intensity (ASEAN Centre for Energy, 2018). Improvement and emphasis of environmental policies, law and regulations are needed especially in the trading activities among countries in order to minimize the emissions of carbon dioxide. Joining force in term of technological and skill capacity between the ASEAN-5 countries will expedite the development and execution of the environmental-friendly production. Moreover, carbon tariff is perceived as one of the policy that should be seriously implemented in ASEAN-5. Japan has enforced the carbon tax since 2012 on fossil fuels (Eva, 2016). Besides Japan, China and South Korea are also implemented the carbon tax in Asian. This study suggests that the data before 1995 for all the variables should be provided and analysed. Besides, future research could be done by using other variables. This will help to derive various findings for environmental degradation. Nevertheless, the time frame is also a limitation for conducting this study. The time frame of this study is from 1995 to 2014, 20 years research.

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