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Environmental Degradation and Economics Growth: Testing the Environmental Kuznets Curve Hypothesis (EKC) in Six ASEAN Countries

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ENVIRONMENTAL DEGRADATION AND ECONOMIC GROWTH: TESTING ENVIRONMENTAL KUZNETS CURVE HYPOTHESIS IN SIX ASEAN COUNTRIES

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ABSTRACT

Environmental issues have been widely reported in recent years. From climate change to plastic waste, environmental quality is deteriorating at an unprecedented speed in human history. Environmental degradation is believed to have tied to the different stages of a country's economic growth, as the Environmental Kuznets Curve (EKC) hypothesis suggested. Despite the proliferation of research about the EKC hypothesis, no consensus has been reached in the field regarding the validation of the hypothesis. This paper employs time-series methods to empirically investigates the impacts of economic growth, trade openness, energy consumption, and foreign direct investment on environmental degradation in six selected ASEAN countries, from the period between 1971 to 2013, to examine the validity of the EKC hypothesis. First, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests were applied to test the stationarity of selected variables, Johansen Cointegration test and ARDL bound testing for cointegration test, ARDL models were constructed to find the potential long- and short-run relationships. The results showed the presence of EKC in Singapore, Thailand, and Vietnam, and no evidence of EKC was found in Malaysia, Philippines, and Indonesia.

Keywords: *Environmental Kuznets Curve, ASEAN, Environmental Degradation, Economic Growth, CO_2 Emissions, Energy Consumption, Trade, Foreign Direct Investment*

I. INTRODUCTION

Environmental issues have been widely reported in recent years. From climate change to plastic waste to deforestation, environmental quality is deteriorating at an unprecedented speed in human history, as many countries put economic growth as their top priority at the expense of the environment. Global warming has been reported to be posing severe threats to the future of humanity. The primary cause of this global phenomenon is contributed by the emissions of greenhouse gases, with carbon dioxide (CO_2) emissions sharing the largest portion. There has been a 60 percent increase in global CO_2 emissions from 1990 to 2013, which causes a rise of 0.8 degrees Celsius in mean global temperature when combining with other greenhouse gases (Khokhar, 2017). A similar report from Intergovernmental Panel on Climate Change (2014) explained that 78 percent of CO_2 emissions in the shared greenhouses gases comes from the fossil fuel combustion from 1970 to 2010. Environmentalists have repeatedly warned that the consequences of the rising temperature will be a disaster if the levels of CO_2 and other greenhouse gas emissions are left uncapped and continue to rise.

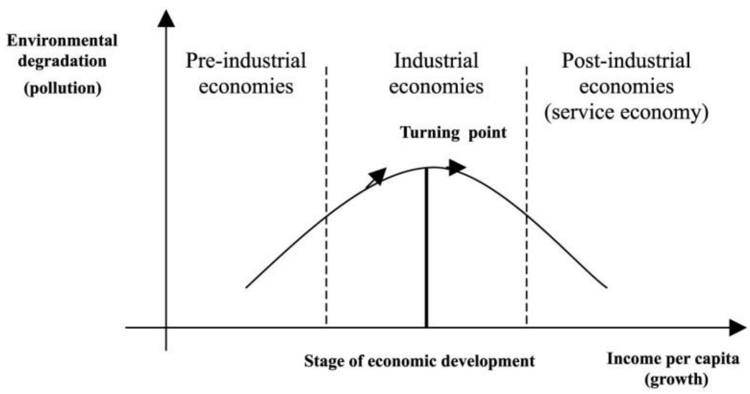
As global warming becomes a dire issue, a great number of researches in the past decades has been focused on examining the link between CO_2 emissions levels and the pace of environmental degradation. By using CO_2 emissions level as a proxy of environment, some studies revealed that the deterioration of environment is associated with the economic growth of a country (Azomahou et. Al, 2006; Mladenović et al, 2016). To dive deeper into the complexity of the subject, some researchers also incorporated exogenous factors such as trade openness, foreign direct investment, energy usage, and population growth in their study along with growth rate, in searching for a better understanding of this problem and for environmental policies implications. Regardless of the growing research in the realm, the conclusion of economic growth affecting environmental degradation due to the CO_2 emissions release from economic activities remains an enigma, as each study applied a slightly different strategy or method while researching this topic.

This paper, therefore, intends to investigate the relationship between environmental degradation and economic growth with the presence of energy consumption, trade openness, and foreign direct investment in six selected Southeast Asia countries.

(A) ENVIRONMENTAL KUZNETS CURVE (EKC) HYPOTHESIS

Environmental degradation is believed to have tied to the stages of economic growth. Environmental experts argued that pursuing solely on economic growth will put the environment in jeopardy. An early piece of research by Grossman and Krueger (1991,1995) investigated the nexus of environmental degradation and economic growth. They noticed that there exists an inverted U-shaped curve identical to the Kuznets curve, and named it the Environmental Kuznets Curve (EKC). Kuznets (1955) proposed that economic inequality will first increase and then decrease after reaching the highest point where the economy continues to develop throughout the process, showing an inverted U-shaped curve among the relationship of economic inequality and income per capita. Analogously, the EKC hypothesis suggested that the environment will initially deteriorate as an economy takes off. However, the environment quality of a country will start improving once the income level hit a turning point. In other words, the hypothesis implies there is a self-fixing mechanism between environmental degradation and economic growth, which the best solution to solving a country's environmental deterioration is its economic growth.

Equally important, some studies also suggested the relationship between environmental quality and growth is an N-shaped or inverted N-shaped curve, instead of an inverted U-shaped curve (Churchil, Inekwe, Ivanovski, & Smyth, 2018), or more generally, the shape of curves may vary as each country develops in a different pace (Hwa, Li, Khan, & Hong, 2016). The inverted U-shaped curve which EKC proposed is illustrated in figure 1



Source: Panayotou (1993)

Figure 1. Environmental Kuznets Curve
Sources: Panayotou (1993)

Since the 1990s, a proliferation of empirical studies has attempted to examine the relationship between economic growth and environmental quality in different countries under the EKC hypothesis. Although many studies have repeatedly examined the EKC hypothesis, validation of the hypothesis remains inconclusive because the results vary from one study to another. This is mainly due to the selection of variables, countries, and timespan, or more specifically, the specification of the econometrics model constructed in each study (Ahmad, at al., 2017; Harbaugh, Levinson, and Wilson, 2002). Nevertheless, the EKC hypothesis provided a basic framework to how environmental degradation related to economic growth. As a reason, this paper intends to investigate the impacts of economic growth, foreign direct investment (FDI), trade liberalization, and energy consumption on the environmental degradation in six selected countries of the Association Southeast Asia Nations (ASEAN), from the period of 1971 to 2013, to examine the validity of the EKC hypothesis.

(B) ASEAN CONTEXT

With more than 600 million population and plenty of natural resources, Southeast Asia is regarded as one of the fast-growing regions in the world for the past couple of decades. The regional economic bloc-ASEAN was first established in 1967, with the notions of promoting economic collaboration, maintaining regional peace and stability, and enhancing cultural exchange among its member states. According to Wood (2017), published on World Economic Forum, "If ASEAN were a country, it would be the seventh-largest economy in the world, with a combined GDP of $2.6 trillion in 2014. By 2050 it is projected to rank as the fourth-largest economy". As a region now experiencing a high economic growth, ASEAN nations are in dire dilemma of choosing between sacrificing the environment by prioritizing the robust growth or protecting the environment by forgoing the economic boom.

An extensive amount of literature about the EKC hypothesis in the context of ASEAN have been predominantly focusing on the five founding members (Singapore, Malaysia, Indonesia, Thailand, & Philippines) of the organization, the rest of the member states (Vietnam, Laos, Myanmar, Cambodia, and Brunei) are often being excluded mainly due to the incompleteness of the data available for research. Because of this, painting a full picture of the environmental condition vis-à-vis to the growth rate in ASEAN can be difficult without including most of its member states. For this reason, the goal of this paper is to study the effects of growth, FDI, trade, energy usage with respect to the environmental quality under the assumption of the EKC hypothesis, to understand which variables are significant to the environmental degradation in the selected ASEAN nations.

II. LITERATURE REVIEW

Vast amounts of studies have examined the impacts of economic growth, FDI, trade, and energy usage on environmental degradation, which are represented by CO_2 emission in many studies, and claimed that there is indeed an inverted U-shaped relationship as the EKC hypothesis suggested. On the contrary, some researchers questioned the validity of the EKC hypothesis, as their studies found only a little empirical evidence to support the inverted U-shaped relationship between economic growth and environmental degradation.

Narayan and Narayan (2010) studied the EKC hypothesis on 43 developing countries based on the income elasticity in short- and long-run, which they found that 35 percent of the selected countries showed a reduction in CO_2 emission level as income increased, and the emission was lower in the long-run as opposed to in the short-run as suggested by EKC hypothesis. The research of Apergis and Ozturk (2015) in Vietnam from 1990 to 2011, supported the existence of an inverted-U shaped relationship between CO_2 emission and income per capita. In their panel study regarding the linkage of economic growth, financial and instructional development on environmental degradation, Tamazian and Rao (2010) found that economic development did lower the environmental quality, but the degradation began to reduce when both financial and institutional variables were taken into account, which confirmed that EKC hypothesis is valid.

Conversely, Adu and Denkyirah (2017) incorporated CO_2 emission and combustible renewable waste as their indicators of the environment when examining the EKC hypothesis. The result concluded that economic growth negatively impacts in West Africa in the short-run as the two pollutants increased along the economy, but no significant decrease was found in both pollutant indicators in the long-run, meaning that EKC hypothesis is illegitimate. Harbaugh, Levinson, and Wilson (2002) used three types of air pollutants (SO_2, smoke, and TSP) as the environmental variable and national income level to test the robustness of the EKC hypothesis, they argued that there were no significant amounts of empirical evidence available to justify the EKC hypothesis because both pollutions and growth are sensitive to sample selections and model specifications.

In the realm of energy consumption, Beak and Kim (2013) studied the environment and economic growth by looking at the level of energy consumption, as well as the fossil fuels and nuclear energy in electricity production in Korea. Their study showed that the environment started to degrade when income per capita increased, the degradation has improved since the last couple of decades while the economy continues to grow, which subsequently proved the existence of EKC hypothesis in this case. Furthermore, Gokmenoglu and Taspinar (2016) tested the EKC hypothesis in Turkey from 1974 to 2010 by incorporating CO_2 emission, energy consumption, FDI, and growth rate. The results indicated that the air pollution decreases when GDP increases in the long-run, whereas a reverse relationship between the two variables is true in the short-run, thus concluded that EKC hypothesis is valid.

Ahmad et al. (2017), on the other hand, applied Autoregressive Distributed Lag (ARDL) method to test the EKC hypothesis in Croatia across a timespan of 20 years. They used CO_2 emission as the dependent variable for the environment to find the relationship with economic growth, and their result showed the hypothesis only holds in the long-run and with no conclusive evidence available in the short-run. Similarly, Le and Quah (2018) explored the nexus of CO_2 emission, energy consumption and economic growth in fourteen selected countries in Asia-Pacific. Their study discovered that the EKC hypothesis holds in high-income countries, whereas the opposite of the hypothesis was true for low- and middle-income countries, which showed that economic growth reduced the CO_2 emission rather than increased it in the short-run. Lastly, Pau, Yu, and Yang (2011) researched the relationship between environment, growth, and energy consumption in Russia from 1990 to 2007 by using CO_2 emission level as an environmental indicator. The results showed that economic growth has an insignificant impact on CO_2 emission, which rejected the EKC hypothesis. They also stated that enforcing effective economic and energy policies could reduce the CO_2 emission level without suppressing economic development.

Several studies have found that EKC hypothesis is valid when incorporated FDI and/or trade into the model. Twerefou, Danson-Mensah, and Bokpin (2017) investigated the impacts of globalization on the environment quality by using growth, foreign direct investment (FDI), and trade as their indicators. They validated the EKC hypothesis in their study as there exists a positive relationship between the environment and economic growth, which portended that the expansion of globalization will inevitably cause the environmental quality to deteriorate in Sub-Saharan Africa countries. Additionally, Hitam and Borhan (2012) examined the pollution and FDI in Malaysia for the period of 1965 to 2010 and stated that environmental degradation was linked to the level of FDI, which higher level of FDI will have harmful effects on the environment, therefore concluded that the EKC hypothesis is true. The research of Hwa, Li, Khan, and Hong (2016) concluded that the EKC hypothesis exists in the five founding members of ASEAN when including FDI and trade as controlled variables. Their results, however, suggested that the relationship between CO_2 emission and economic growth in both short- and long-run has shown an inverted-S shaped, rather than the orthodox inverted U-shaped.

In contrast, Zhu, Duan, Guo, and Yu (2016) utilized a panel quantile regression method to search for the effects of growth, FDI, and energy consumption on CO_2 emission level in five selected ASEAN nations. Their study revealed that the effects of each variable on CO_2 emission level were heterogeneous in different quantiles, which indicated that there were no consistent results able to validate the EKC hypothesis holds for all five of the ASEAN nations. In a time-series data analysis of Pakistan, Ahmed and Long (2012) deployed CO_2 emission level as the environment variable and investigated its relationship with growth, energy consumption, trade, and population density. Their study found that EKC hypothesis holds in the long-run because all explanatory variables were statistically significant to the CO_2 emission level, but no relationship was found in the short-run, which failed to prove the existence of EKC hypothesis.

To contribute to the existing EKC hypothesis literatures, this paper attempts to research the environment-income nexus with the presence of energy consumption, foreign direct investment, and trade openness in selected ASEAN countries, from 1971 to 2013, by applying time-series econometric tools.

III. THE EMPIRICAL FRAMEWORK & DATA

(A) EMPIRICAL MODEL

This paper employs time-series methods to examine the environment-income-energy-trade-FDI nexus in selected ASEAN countries. Following the empirical research in environmental economics, a time-series empirical model of which constructed to evaluate EKC hypothesis in each ASEAN country is expressed as:

$$(lnCO_2)_t = \beta_0 + \beta_1\left(lnGDP_{pc}\right)_t + \beta_2\left(lnGDP_{pc}\right)^2{}_t + \beta_3\,(lnEC)_t + \beta_4\,(lnFDI)_t + \beta_5\,(lnTR)_t + \varepsilon_t \tag{1}$$

where the CO_2 is the carbon dioxide emission level in period t, measures by metric tons per capita. It also serves as a proxy for environmental degradation. All dependent and independent variables are transformed into logarithm form to interpret the elasticity of the parameters. $GDPpc$ represents income per capita, measures in constant 2010 US dollar. EC is energy consumption measured in kg of oil equivalent per capita per capita. Moreover, FDI is the net inflow of foreign direct investment calculated in constant 2010 US dollar, whereas TR represents trade level measuring as the sum of export and import to GDP ratio in constant 2010 US dollar. Lastly, β_0 and ε_t are the constant term and standard error term.

GDP per capita ($GDPpc$), energy consumption (EC), net inflow of foreign direct investment (FDI), and trade openness (TR) are all expected to have a positive relationship with the level of CO_2 emission level (CO_2), whereas the square of GDP per capita (GDP_{pc}^2) is presumed to be negatively related to CO_2 emission level. According to Twerefou, Danson-Mensah, and Bokpin (2017), three potential outcomes may occur when regress the empirical model:

(1) When $\beta_1 > 0$ and $\beta_2 = 0$, there exists a linear relationship between CO_2 emission and economic growth, suggesting that an increasing growth rate leads to an increasing in CO2 emission.
(2) When $\beta_1 < 0$ and $\beta_2 > 0$, there exists a U-shaped relationship between CO_2 emission and economic growth.
(3) When $\beta_1 > 0$ and $\beta_2 < 0$, there exists an inverted U-shaped curve and validate EKC hypothesis.

Moreover, the estimation of turning point in EKC hypothesis can be expressed as followed $GDP_{pc}^* = -(\beta_1 / 2\beta_2)$. As the income per capita ($\mathrm{GDP_{pc}}$) is represented in logarithm form, the peak of $\mathrm{GDP_{pc}^*}$ can be calculated by using the formula proposed by de Bruyn and Opschoor (1998), which specified as $GDP_{pc}^* = e^{-(\beta_1/2\beta_2)}$.

(B) UNIT-ROOT TEST & COINTEGRATION TEST

Two different unit-root tests, augmented Dickey-Fuller (ADF) test and Philips-Perron (PP) test, are used to examine if all variables have presence of unit root. The null hypothesis of both tests is stated as variable has unit-root, which means the variable is non-stationary. If the parameters of the variables are not statistically significant, then the null hypothesis can be rejected. All variables are expected to be non-stationary at level, $I(1)$ process, and stationary after converting to first difference, $I(0)$ process.

After performing both stationary tests, Johansen cointegration test is utilized to check whether there exhibit combinations of cointegration among the chosen variables. The null hypothesis of Johansen cointegration states that there is no cointegration among selected variables in the long-run. If null hypothesis is rejected, then the existence of long-run relationship among the variables can be established.

(C) AUTOREGRSSIVE DISTRIBUTION LAG (ARDL) MODEL

To further the test of cointegration, Autoregressive Distribution Lag (ARDL) method is applied for this regard. ARDL method developed by Pesaran et al. (2001) is particularly useful in testing the cointegration among variables.

Several studies (Saboori, Sulaiman, & Mohd, 2012; Saboori & Sulaiman, 2013; Gokmenoglu & Taspinar, 2016; Ahmad et al., 2017) employed ARDL method to test cointegration mainly because of three major advantages. Firstly, the conventional cointegration techniques such as Johansen cointegration test and Engle-Granger cointegration test require all independent variables to be at a same level of time-series process, for example, they must all be at $I(1)$ process. ARDL method, on the other hand, does not require all variables to have the same process, it can be applied whether the variables are $I(1)$, $I(0)$, or a mixture of both, but no variables can be in $I(2)$. Second reason is that the impacts of independent variables on dependent variable in both long- and short-run can be assessed simultaneously, which makes distinguishing long- and short-run effects relatively effortless. Lastly, Pesaran and Shin (1998) found that consistency in the OLS estimators of the short-run parameters and the ARDL based estimators of the long-run coefficients in small sample sizes.

Corresponding to equation (1) long-run model, the short-run model is written as:

$$\Delta\, ln(CO_2)_t = \alpha_0 + \sum_{k=1}^{n} \alpha_{1k} \Delta\, ln(CO_2)_{t-k} + \sum_{k=0}^{n} \alpha_{2k} \Delta\, ln(GDP_{pc})_{t-k} + \sum_{k=0}^{n} \alpha_{3k} \Delta\, ln\, (GDP_{pc})^2{}_{t-k} + \sum_{k=0}^{n} \alpha_{4k} \Delta\, ln(EC)_{t-k} + \sum_{k=0}^{n} \alpha_{5k} \Delta\, ln(FDI)_{t-k} + \sum_{k=0}^{n} \alpha_{6k} \Delta\, ln(TR)_{t-k} + \phi_1 ln(CO_2)_{t-1} + \phi_2 ln(GDP_{pc})_{t-1} + \phi_3 ln\, (GDP_{pc})^2{}_{t-1} + \phi_4\, ln(EC)_{t-1} + \phi_5\, ln(FDI)_{t-1} + \phi_6 ln(TR)_{t-1} + \varepsilon_t \quad (2)$$

where in equation (2) α_{1k}, α_{2k}, α_{3k}, α_{4k}, α_{5k}, and α_{6k} represent the short-run error-correction dynamics, ϕ_1, ϕ_2, ϕ_3, ϕ_4, ϕ_5, and ϕ_6 show the long-run dynamics, α_0 is constant term, and ε_t is white noise error term. The null hypothesis of ARDL bound testing for cointegration is $H_0\colon \phi_1 = \phi_2 = \phi_3 = \phi_4 = \phi_5 = 0$, which suggest no cointegration, and the alternative hypothesis is $H_0\colon \phi_1 \neq \phi_2 \neq \phi_3 \neq \phi_4 \neq \phi_5 \neq 0$. Pesaran et al. (2001) introduced two set of critical values for which known as lower bound and upper bound. The former is for $I(0)$ variables, whereas the latter considers $I(1)$ variables. When the computed F-statistics is smaller than lower bound critical value, then null hypothesis cannot be rejected, and null hypothesis can be rejected when the F-statistics is greater than upper bound critical value. If the F-statistics fall between lower and upper bound, then the result is inconclusive.

When the F-statistics fall in the inconclusive zone, Banarjee et al. (1998) explained the long-run relationship can be established if the error-correction term is negative and significant statistically. Corroborating with Banarjee et al. (1998), Saboori and Sulaiman (2013) suggested that substituting all lagged level variables with error-correction term, and then test if the coefficients are statistically significant. After establishing the existence of long-run relationship, error-correction model (ECM) is employed to estimate the short-run coefficients and error-correction term. Equation (3) shows the general formula of ECM:

$$\Delta\, ln(CO_2)_t = \alpha_0 + \sum_{k=1}^{n} \alpha_{1k} \Delta\, ln(CO_2)_{t-k} + \sum_{k=0}^{n} \alpha_{2k} \Delta\, ln(GDP_{pc})_{t-k} + \sum_{k=0}^{n} \alpha_{3k} \Delta\, ln\, (GDP_{pc})^2{}_{t-k} + \sum_{k=0}^{n} \alpha_{4k} \Delta\, ln(EC)_{t-k} + \sum_{k=0}^{n} \alpha_{5k} \Delta\, ln(FDI)_{t-k} + \sum_{k=0}^{n} \alpha_{6k} \Delta\, ln(TR)_{t-k} + \theta * ECT_{t-1} + \varepsilon_t \quad (3)$$

where $\theta * ECT_{t-1}$ is the error-correction term representing the speed of adjustment in which how fast the variables adjust to the long-run equilibrium level. In addition, diagnostic tests such as normality, serial correlation, and heteroskedasticity tests are applied in order to ensure the goodness-of-fit of the estimated models.

(D) DATA

This paper applied annual data across a timespan of 43 years, from 1971 to 2013, in the six selected ASEAN nations, which are Singapore, Malaysia, Indonesia, Thailand, Philippines, and Vietnam. All data collected are secondary data. Carbon dioxide emissions (CO_2) and energy consumption (EC) are extracted from the World Development Indicator (WDI), GDP per capita ($GDPpc$) and inward foreign direct investment (FDI) are collected from United Nations Conference on Trade and Development (UNCTAD), and trade (TR) data is gathered from International Monetary Fund (IMF). Due to the severe lack of data availability in Cambodia, Myanmar, Brunei, and Lao Republic, these four countries are excluded in this analysis. Table 1 provides a summary for the definition, notation, measurement, and expected sign of all variables.

Table. 1 - Definition, notation, and expected sign of variables

Variables	Types of variables	Notation	Measurement	Expected sign
Carbon dioxide emissions	Dependent	CO2	Carbon dioxide emissions (metric tons per capita)	No prediction
GDP per capita	Independent	GDP	GDP per capita (constant 2010 US$)	Positive
GDP per capita squared	Independent	GDP2	Squared of GDP per capita (constant 2010 US$)	Negative
Energy consumption	Independent	EC	Energy use (kg of oil equivalent per capita)	Positive
Foreign direct investment (net inflow)	Independent	FDI	Foreign direct investment, net inflows (constant 2010 US$)	Positive
Trade	Independent	TR	(Export+Import)/GDP (constant 2010 US$)	Positive

IV. EMPIRICAL RESULTS

(A) UNIT-ROOT TEST & COINTEGRATION TEST

Two unit-root tests, augmented Dickey-Fuller test and Phillips-Perron test, were performed to examine the stationarity of all selected variables. The summary of the unit-root test results is presented in Table 2. The results obtained from ADF test and PP test highly suggested that all series have unit-root at level, which means that they are non-stationary and are $I(1)$ process. Furthermore, the results also showed that all variables become $I(0)$ process after converting to first difference, which indicated that they are free from unit-root and are stationary at first difference.

After establishing all variables were stationary at first difference, Johansen cointegration test was applied to check the cointegration among selected variables. The summary of Johansen cointegration test is illustrated in Table 3. From the table 3, the results suggest that all series are cointegrated at some combinations, which subsequently indicates that there exist long-run relationships among the variables.

Table 2 – Results of ADF Test and PP Test

Country		Variables	ADF Test Statistics			PP Test Statistics		
			Trend & Intercept	Intercept	None	Trend & Intercept	Intercept	None
Singapore	Level	ln (CO_2)	-3.0984	-2.5700	-0.0789	-3.0046	-2.6088*	0.1458
		ln (GDPpc)	-2.5970	-1.6907	1.9701	-2.6318	-2.6412*	3.9538
		ln (GDPpc)^2	-2.6355	-1.2947	2.0210	-2.3481	-1.7670	3.8074
		ln (EC)	-1.5794	-1.9657	1.5232	-1.5152	-1.9930	1.6200
		ln (FDI)	-4.7529***	-1.9970	1.7609	-4.7234***	-1.3807	3.2786
		ln (TR)	-2.6543	-2.9819**	0.0604	-2.6113	-2.9640**	0.0766
	1st difference	Δ ln (CO2)	-6.3541***	-6.3675***	-6.4569***	-8.0192***	-7.7124***	-7.8511***
		Δ ln (GDPpc)	-3.7410**	-3.5821**	-2.6969***	-3.6335**	-3.4445**	-2.5741**
		Δ ln (GDPpc)^2	-3.8677**	-3.8093***	-2.7183***	-3.8154**	-3.7342***	-2.7183***
		Δ ln (EC)	-7.3032***	-7.1523***	-6.8599***	-7.3130***	-7.1523***	-6.8617***
		Δ ln (FDI)	-6.5967***	-6.1612***	-7.8905***	-26.900***	-19.574***	-8.1649***
		Δ ln (TR)	-6.9101***	-6.6297***	-6.6639***	-6.9070***	-6.6255***	-6.6590***
Malaysia	Level	ln (CO_2)	-2.1168	-0.7440	2.3785	-2.1326	-0.7440	2.5315
		ln (GDPpc)	-3.2337*	-2.1257	3.9337	-3.2337*	-2.1257	3.5453
		ln (GDPpc)^2	-2.7549	-1.3276	3.7403	-2.8361	-1.3276	3.7403
		ln (EC)	-1.9929	-0.9897	3.9731	-2.0328	-1.4455	4.6310
		ln (FDI)	-3.6516**	-2.1682	0.7346	-3.5886**	-2.0149	1.1190
		ln (TR)	-0.5084	-1.5958	-0.9849	-0.4409	-1.5906	-0.7388
	1st difference	Δ ln (CO_2)	-7.7410***	-7.8174***	-6.3481***	-7.7274***	-7.7583***	-6.5236***
		Δ ln (GDPpc)	-5.1887***	-5.0920***	-4.0188***	-5.1232***	-5.0104***	-3.8701***
		Δ ln (GDPpc)^2	-5.3878***	-5.4036***	-4.2045***	-5.3352***	-5.3479***	-4.0919***
		Δ ln (EC)	-6.7843***	-6.7102***	-4.8387***	-9.4111***	-7.0083***	-4.9210***
		Δ ln (FDI)	-8.4637***	-8.5236***	-8.2981***	-8.5227***	-8.5814***	-8.3288***
		Δ ln (TR)	-6.1624***	-5.6755***	-5.4797***	-6.1945***	-5.6743***	-5.5064***
Philippines	Level	ln (CO_2)	-1.5047	-0.9333	-1.0608	-1.7919	-1.2573	-1.1343
		ln (GDPpc)	-2.1372	-1.3042	3.7132	-2.4351	-1.3035	2.7657
		ln (GDPpc)^2	-1.6216	-0.6334	3.6546	-2.1007	-0.7947	2.7454
		ln (EC)	-2.4503	-2.5642	0.3549	-2.4470	-2.5786	0.4190
		ln (FDI)	-4.5333***	-3.0039**	0.6228	-4.4630**	-2.3058	0.9637
		ln (TR)	-0.2245	-1.3247	-1.1748	-0.6311	-1.4204	-1.1186
	1st difference	Δ ln (CO_2)	-5.6692***	-5.7114***	-5.6950***	-5.7576***	-5.7995***	-5.7859***
		Δ ln (GDPpc)	-4.3716***	-4.3985***	-3.5817***	-4.4534***	-4.4640***	-3.5695***
		Δ ln (GDPpc)^2	-4.4757***	-4.5333***	-3.6679***	-4.5533***	-4.6063***	-3.6799***
		Δ ln (EC)	-8.9281***	-8.7972***	-8.8499***	-8.5859***	-8.4529***	-8.5051***
		Δ ln (FDI)	-9.4473***	-9.3910***	-9.2234***	-13.263***	-11.629***	-10.121***
		Δ ln (TR)	-5.3258***	-5.0068***	-5.0089***	-5.3675***	-5.0500***	-5.0463***
Indonesia	Level	ln (CO_2)	-3.3918*	-1.5387	-1.7845*	-3.2868*	-1.7885	-1.7594*
		ln (GDPpc)	-2.7305	-1.8887	2.6584	-2.7894	-1.8621	2.4170
		ln (GDPpc)^2	-2.1299	-1.0834	2.5126	-2.2967	-1.0927	2.4425
		ln (EC)	-1.2301	-1.0311	4.3041	-1.2301	-1.0769	4.5184
		ln (FDI)	-4.6162***	-4.6057***	-0.2197	-4.6045***	-4.5933***	-0.0326
		ln (TR)	-4.5067***	-3.8248***	-1.1152	-4.5306***	-3.8043***	-1.3266
	1st difference	Δ ln (CO_2)	-5.9419***	-5.9757***	-4.9286***	-5.5454***	-5.4411***	-4.9286***
		Δ ln (GDPpc)	-5.7837***	-5.7681***	-4.9960***	-5.7751***	-5.7550***	-5.0172***
		Δ ln (GDPpc)^2	-5.8891***	-5.9566***	-5.1409***	-5.8802***	-5.9481***	-5.1808***
		Δ ln (EC)	-6.5466***	-6.4875***	-4.6667***	-6.5832***	-6.4956***	-4.7409***
		Δ ln (FDI)	-9.3430***	-9.4468***	-9.5601***	-16.9327***	-15.5857***	-15.5551***
		Δ ln (TR)	-8.5685***	-8.5888***	-8.6333***	-9.5195***	-9.3022***	-9.3184***
Thailand	Level	ln (CO_2)	-1.4189	-0.8927	0.6035	-1.1017	-1.1183	0.7056
		ln (GDPpc)	-2.9211	-1.5876	2.2255	-2.3018	-1.5470	3.5264
		ln (GDPpc)^2	-2.7430	-0.9989	2.1359	-2.1910	-0.8551	3.3096
		ln (EC)	-2.0108	0.2807	5.5937	-2.0339	0.0647	4.2686
		ln (FDI)	-3.8234**	-1.0755	1.4124	-3.9052**	-1.3257	1.7079
		ln (TR)	-2.4624	-1.4036	-2.7555***	-2.5512	-1.4036	-2.8576***
	1st difference	Δ ln (CO_2)	-4.3909***	-4.3807***	-3.2274***	-4.3886***	-4.3780***	-3.2274***
		Δ ln (GDPpc)	-4.1307**	-4.0467***	-2.9767***	-4.1307**	-4.0467***	-2.9483***
		Δ ln (GDPpc)^2	-4.1508**	-4.1797***	-3.0918***	-4.1508**	-4.1797***	-2.9379***
		Δ ln (EC)	-4.7380***	-4.7736***	-3.1779***	-4.8373***	-4.8691***	-3.2184***
		Δ ln (FDI)	-9.0663***	-9.1804***	-8.7904***	-10.1200***	-10.2067***	-8.7904***
		Δ ln (TR)	-7.1648***	-7.1418***	-6.3062***	-7.2400***	-7.1514***	-6.3120***
Vietnam	Level	ln (CO_2)	-2.3637	0.4604	-0.5859	-2.4578	0.3900	-0.6524
		ln (GDPpc)	-2.5052	1.0080	1.9872	-1.6121	0.8460	2.9006
		ln (GDPpc)^2	-1.8352	0.6112	2.6395	-1.1709	1.6529	3.7871
		ln (EC)	-1.6393	2.0739	2.2437	-1.6481	1.6228	2.0559
		ln (FDI)	-3.9011**	-1.2215	-0.1613	-4.0036**	-0.8458	0.3242
		ln (TR)	-4.2508***	-2.0378	-2.3630**	-4.0722**	-1.9039	-2.6193
	1st difference	Δ ln (CO_2)	-7.6112***	-6.7186***	-6.5026***	-7.5886***	-6.7274***	-6.5593***
		Δ ln (GDPpc)	-3.5466**	-2.7504**	-1.5808	-4.9301***	-4.2657***	-4.0204***
		Δ ln (GDPpc)^2	-3.6436**	-4.4402***	-3.4077***	-4.8403***	-4.2384***	-3.8387***
		Δ ln (EC)	-6.8838***	-5.2200***	-4.5520***	-6.8817***	-5.4860***	-4.8696***
		Δ ln (FDI)	-11.1632***	-11.1907***	-10.5451***	-10.5498***	-10.5704***	-9.8846***
		Δ ln (TR)	-3.6558**	-3.4027**	-7.7603***	-23.0100***	-16.2871***	-7.9915***

Note: *, **, and *** represents 10%, 5%, and 1% level of significance, respectively. ADF & PP Null hypothesis: Variable has unit root.

Table 3 – Results of Johansen Cointegration Test

Country		Hypothesized of No. CE(s)	Trend Statistics	Max-Eigen Statistics
Singapore	Intercept	None	97.5216 *	43.9269 *
		At most 1	53.5947	17.3135
		At most 2	36.2812	16.6382
		At most 3	19.6429	10.6739
		At most 4	8.9689	7.0011
		At most 5	1.9678	1.9678
	Intercept w/ Trend	None	153.3392 *	71.3809 *
		At most 1	81.9582	36.2116
		At most 2	45.7465	16.6646
		At most 3	29.0819	14.0869
		At most 4	14.9949	9.0176
		At most 5	5.9773	5.9773
Malaysia	Intercept	None	116.3160 *	48.4279 *
		At most 1	67.8880	35.5351 *
		At most 2	32.3528	15.3320
		At most 3	17.0208	12.1121
		At most 4	4.9087	3.6937
		At most 5	1.2149	1.2149
	Intercept w/ Trend	None	148.9293 *	59.6061 *
		At most 1	89.3231 *	35.5618
		At most 2	53.7612	27.8581
		At most 3	25.9031	14.7578
		At most 4	11.1452	7.5403
		At most 5	3.6049	3.6049
Philippines	Intercept	None	148.8800 *	68.2788 *
		At most 1	80.6012 *	27.8639
		At most 2	52.7372 *	25.8239
		At most 3	26.9132	19.8582
		At most 4	7.0550	6.6125
		At most 5	0.4424	0.4424
	Intercept w/ Trend	None	172.8334 *	68.6450 *
		At most 1	104.1884 *	32.7756
		At most 2	71.4127 *	27.2643
		At most 3	44.1483 *	22.6416
		At most 4	21.5066	16.0938
		At most 5	5.4128	5.4128
Indonesia	Intercept	None	180.7117 *	66.7236 *
		At most 1	113.9881 *	52.1735 *
		At most 2	61.8146 *	42.5643 *
		At most 3	19.2502	15.1005
		At most 4	4.1497	3.7029
		At most 5	0.4467	0.4467
	Intercept w/ Trend	None	191.9811 *	70.9876 *
		At most 1	120.9934 *	52.3862 *
		At most 2	68.6071 *	43.1198 *
		At most 3	25.4873	15.1007
		At most 4	10.3866	6.8460
		At most 5	3.5405	3.5405
Thailand	Intercept	None	141.6930 *	65.7535 *
		At most 1	75.9394 *	35.0111 *
		At most 2	40.9283	20.1938
		At most 3	20.7344	13.1235
		At most 4	7.6108	7.4360
		At most 5	0.1747	0.1747
	Intercept w/ Trend	None	160.3005 *	65.7804 *
		At most 1	94.5200 *	39.4748 *
		At most 2	55.0452	27.7877
		At most 3	27.2574	13.1462
		At most 4	14.1111	9.5340
		At most 5	4.5771	4.5771
Vietnam	Intercept	None	106.0117 *	38.0404
		At most 1	67.9712	29.5334
		At most 2	38.4378	17.2579
		At most 3	21.1799	10.8849
		At most 4	10.2950	9.6355
		At most 5	0.6595	0.6595
	Intercept w/ Trend	None	166.9689 *	69.9443 *
		At most 1	97.0245	34.1617
		At most 2	62.8628	28.7867
		At most 3	34.0760	16.8387
		At most 4	17.2372	10.5109
		At most 5	6.7263	6.7263

(B) ARDL MODEL

Pesaran et al. (2001) specified that ARDL bound testing can only be applied to series that are in $I(1)$, $I(0)$, or the combination of both, without presence of $I(2)$ in any of the variables. After applying ADF test and PP test to check the stationarity, the result strongly suggests none of the selected variables are $I(2)$. Therefore, it is valid to use ARDL bound testing to check the cointegration between the variables. As the F-statistics is sensitive to the number of lags imposed in the model, Schwarz criterion (SC) is utilized to select the appropriate lags because it chooses the smallest possible lags for the model. Table 4 provides a summary of the results of ARDL cointegration test. The computed F-statistics in Indonesia, Thailand, Vietnam is greater than the upper bound critical values at 5% level of significance, which support the presence of cointegration in these three countries. On the other hand, the F-statistics of Singapore, Malaysia, and Philippines fall into the inconclusive zone at 5% significant level. However, the presence of cointegration can be supported by the statistically significant and negative values of ECT_{t-1} in these three nations. As mentioned, ECT_{t-1} measures the speed of adjustment to which how quickly the short-run shocks can be corrected toward the long-run equilibrium level. Hence, negative and significant values of ECT_{t-1} indicate the short-run shocks are quickly adjusted to the long-run equilibrium in the case of Singapore, Malaysia, and Philippines.

Table 4 – Results of ARDL Cointegration Test

Country	*Singapore*	*Malaysia*	*Philippines*	*Indonesia*	*Thailand*	*Vietnam*
Max. lags imposed	(2,2)	(1,1)	(3,3)	(3,3)	(1,1)	(4,4)
SC selected lags	(1,0,0,0,0,0)	(1,1,0,0,1,0)	(1,1,0,0,2,0)	(3,0,0,3,1,3)	(1,0,0,0,1,0)	(1,4,0,0,3,4)
F-stat selected lags	3.4004 *	3.8218	*5.2185*	*5.5083*	*26.3185*	*19.0406*
ECT_{t-1}	*-0.5226 ****	*-0.5628****	*-0.1466****	*-0.5794****	*-0.6769****	*-0.8743****
Cointegration	Yes	Yes	Yes	Yes	Yes	Yes
Critical values	*Lower bound I (0)*			*Upper bound I (1)*		
10%	2.306			3.353		
5%	2.734			3.92		
1%	3.657			5.256		

Note: *, **, and *** represents 10%, 5%, and 1% level of significance, respectively.

Table 5 reports the results of ARDL estimation in both long- and short-run, as well as diagnostic tests such as Jarque-Bera (JB) normality test, Breusch-Godfrey serial correlation LM test, Durbin-Watson test, and White heteroskedasticity test.

The long-run ARDL estimation shows that GDP per capita is positively related to CO_2 emission level at 5% level of significance while square of GDP per capita is negatively related to CO_2 in the case of Singapore, Thailand, Vietnam. The positively and negatively significant relationship of GDP per capita and square of GDP per capita provide evidence to prove that the EKC hypothesis is valid in Singapore, Thailand, and Vietnam, which suggests the existence of inverted U-shaped relationship. In other word, CO_2 emission will increase by 8.33%, 4.85%, and 14.8% when GDP per capita increases by 1% in Singapore, Thailand, and Vietnam, respectively. These empirical findings is in line with Saboori and Sulaiman (2013) who proved the presence of EKC in Singapore and Thailand. The validity of long-run EKC in Vietnam also supported by Dinh and Shih-Mo (2014) in their research on the environment-income nexus in Vietnam. On the other end of the spectrum, EKC hypothesis are not found in Malaysia, Philippines, and Indonesia because GDP per capita and square of GDP per capita are negatively and positively related to CO_2 emissions, which illustrate an U-shaped relationship instead. The result in Philippines and Indonesia shows consistent with Saboori and Sulaiman (2013), which they explained that the U-shaped relationship suggest that these two countries are in the increasing part of EKC curve. However, the finding of Malaysia is inconsistent with Hitam and Borhan (2012) in which they found the existence of EKC hypothesis the country. In the short-run, the existence of EKC hypothesis can only be found in Thailand and Vietnam, but it was not present in the rest of the four ASEAN countries.

The long-run estimation of energy consumption showed a positive relationship with CO_2 emission in all ASEAN countries with the exception of Singapore and Indonesia. The result indicated that as energy consumption increases, CO_2 emissions in the Malaysia, Philippines, Thailand, and Vietnam will increase. The outputs of energy consumption in the short-run remain largely unchanged with the long-run outputs, except it became insignificant in Philippines. The coefficient of Indonesia has turned positive, albeit it is still insignificant. The result implies that increase in energy demand or consumption will lead to a higher emissions of CO_2 in the related ASEAN nations. This result is expected due to these countries are currently in a rapid developing phase in their economy, which rely on manufacturing sectors that heavily in use of energy in production. Moreover, the inward FDI and trade level are showing a negative relationship in Singapore, Thailand, and Vietnam while positive relationship with the rest of the three ASEAN countries in the long-run. In the short-run, foreign direct investment shows positive impacts on all these countries, except in Singapore and Indonesia. Trade level, on the other hand, have a negative relationship in every ASEAN countries with exception of Malaysia and Philippines. The mixed impacts of FDI on these ASEAN nations are in line with Zhu, Duan, Guo, and Yu (2016), which they found that the effects of FDI varies from countries due to the emission level.

Lastly, JB test results showed that residuals of estimated models are normality distributed as the null hypothesis of normality cannot be rejected at 5% level of significance. Breusch-Godfrey LM test results suggest the models are free from serial correlation problem at 5% significant level. These results are further supported by Durbin-Watson test, as all the statistical values fall within the threshold of 1.6 to 2.4, which is the no serial correlation zone. White test results show all models are free from heteroskedasticity issues, except Thailand, at 5% significant level, but no heteroskedasticity at 1% significant level.

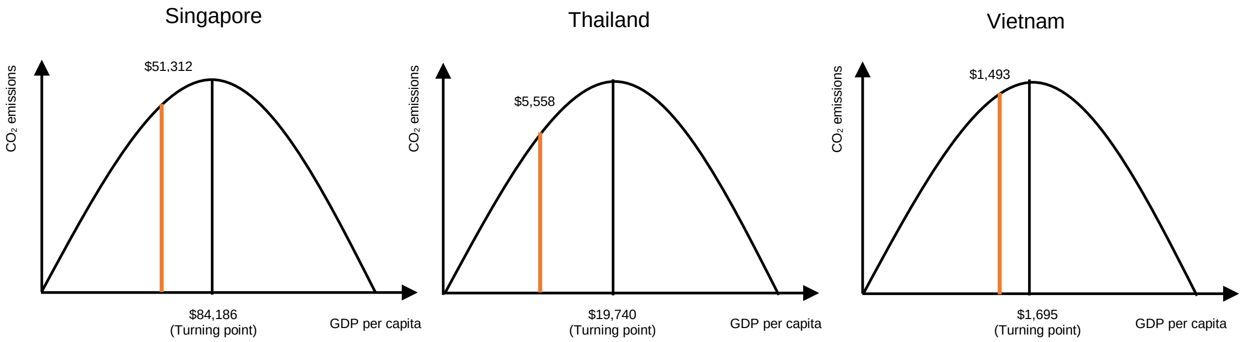
Table 5 – Result of Long- and Short-run ARDL Estimation

Country	*Singapore*	*Malaysia*	*Philippines*	*Indonesia*	*Thailand*	*Vietnam*
ARDL long-run estimation - Dependent variable: ln (CO_2)						
ln(GDPpc)	8.3264** (3.1886)	-4.0463* (2.2936)	-91.2920*** (21.7312)	-7.2234* (3.7826)	4.8463*** (0.6997)	14.7959*** (2.3121)
ln(GDPpc)^2	-0.3671** (0.1566)	0.2411** (0.1173)	6.0719*** (1.4365)	0.5356** (0.2503)	-0.2450*** (0.0477)	-0.9949*** (0.1068)
ln(EC)	-0.1219 (0.3256)	0.6778* (0.3782)	1.8283*** (0.5330)	-0.1147 (0.3139)	0.6978*** (0.1602)	1.5839*** (0.2136)
ln(FDI)	-0.2741 (0.1926)	0.0706* (0.0299)	0.1925** (0.0931)	0.0054 (0.0079)	-0.0332 (0.0226)	-0.0330** (0.0118)
ln(TR)	-0.9556** (0.3793)	0.2216** (0.1267)	-0.1397 (0.1040)	0.5456** (0.2313)	-0.1451*** (0.0230)	-0.5607*** (0.0634)
C	-38.4854 (15.1590)	12.0398 (9.2467)	330.6135 (79.7387)	22.3413 (14.0850)	-26.3771 (2.9751)	-57.5818 (5.0378)
ARDL short-run estimation - Dependent variable: Δln(CO_2)						
Δln(GDPpc)	4.3511 (2.8383)	-1.4838 (1.5524)	-11.9203** (5.1758)	-4.1849 *** (1.1120)	3.2811 *** (0.6138)	11.652 *** (1.6969)
Δln(GDPpc)^2	-0.1919 (0.1411)	0.1357 (0.0824)	0.8901** (0.3454)	0.3103 *** (0.0714)	-0.1658 *** (0.0427)	-0.8698 *** (0.1353)
Δln(EC)	-0.0637 (0.1668)	0.3815 * (0.2052)	0.2680 (0.1723)	0.2424 (0.3087)	0.4724 *** (0.1274)	1.3848 *** (0.3258)
Δln(FDI)	-0.1432 (0.0703)	0.0019 (0.0240)	0.0068 (0.0093)	-0.0130 * (0.0069)	0.0003 (0.0099)	0.0339 *** (0.0115)
Δln(TR)	-0.4993 (0.2554)	0.1247 (0.0893)	-0.0205 (0.0231)	-0.2184 ** (0.0949)	-0.0983 *** (0.02144)	-0.0654 (0.0545)
ΔC	-20.1111 (13.6703)	6.7766 (6.0977)	48.4665 (19.1040)	12.9435 (4.3625)	-17.8568 (2.8719)	-50.3430 (6.7079)
Diagnostic Test						
R^2	0.4042	0.5348	0.7147	0.8398	0.7545	0.9198
JB	4.1888	3.7756	1.6461	0.7055	0.9484	0.4194
LM	0.2268	0.7045	0.2164	0.0403**	0.1281	0.4735
W	0.2661	0.5172	0.9067	0.9429	0.0598*	0.5015
D-W	1.9882	2.1566	2.1364	2.1188	1.8963	1.9136

Note: *, **, and *** represents 10%, 5%, and 1% level of significance, respectively. JB represents the Jarque-Bera test for normality; LM represents the Breusch-Godfrey Serial Correlation LM Test; W represent heteroskedasticity White test.

(C) EKC TURNING POINT

The EKC turning points of Singapore, Thailand, and Vietnam are calculated by $GDP^*_{pc} = -(\beta_1 / 2\beta_2)$. Since the values of the estimated coefficient are measured in logarithm, $GDP^*_{pc} = e^{-(\beta_1/\beta_2)}$ is applied to convert the coefficients into monetary value. The peak of EKC are $84,186, $19,740, and $1,695 for Singapore, Thailand, and Vietnam, respectively. Figure 1 (a-c) graphically illustrates the EKC turning of the three nations. The graphs explicitly show that all three countries are currently on the increasing phase of EKC curve. The result of Singapore is contradicting with the work of Hwa, Li, Khan, and Hong (2016). They found the existence of EKC in Singapore but has passed the turning point, which indicates that it is now at the decreasing phase of EKC curve due to the country has fully developed. The results of Thailand and Vietnam, however, are in line with Saboori and Sulaiman (2013) and Dinh and Shih-Mo (2016). Their research revealed that the two nations are not yet reached the EKC turning point, which supports the fact that both of them are currently at a fast-growing developing phase.



V. CONCLUSION

To reiterate, the goal of this paper was set to examine the validity of EKC hypothesis in six selected ASEAN nations from the period of 1971 to 2013 by employing time-series econometric methods. The empirical results found the presence of EKC in Singapore, Thailand, and Vietnam. The positive and negative coefficient of GDP per capita and square of GDP per capita confirm the inverted U-shaped relationship between GDP per capita and CO_2 emission. The findings portend that GDP per capita grows will have less impacts on the CO_2 emissions in the long-run, which subsequently implies the quality of environment will eventually improve in these countries after reaching a specific point in income growth. In contrast, this study found no empirical evidence to support the validity of EKC in Malaysia, Philippines, and Indonesia. The GDP per capita and square of GDP per capita are negatively and positively with respect to CO_2 emission, which show a U-shaped relationship instead. The mixed outcomes of EKC have captured the asymmetrical economic development in ASEAN countries.

The consumption of energy shows a positive relationship with the CO_2 emissions in Malaysia, Philippines, Thailand, and Vietnam. Although statistically insignificant, Singapore and Indonesia are the only two countries in which energy consumption does not lead to high level of CO_2 emission. As a rapid growing region, developing ASEAN nations are heavily relying on fossil fuels such as gas and oil. ASEAN nations must implement better and stricter energy policies in attempting to reduce pollutions. Reducing in fossil fuels consumption and shifting to renewable energy sources or alternative environmentally friendly energy sources is highly recommended for a more sustainable development of the ASEAN countries.

In the long-run, the results of FDI does not show statistically positive impacts in majority of the selected countries except in Malaysia and Philippines. FDI has negative relationship with respect to CO_2 in Singapore in long- and short-run, albeit statistically insignificant. In Vietnam, FDI is negatively and positively related with CO_2 emissions in long- and short-run respectively. In the countries where FDI shows detrimental effects on the environment, policy makers should impose laws and regulations to curb the transfer of polluting technology when foreign companies looking to set up their manufacturing operations in the host countries. Additionally, ASEAN governments could encourage and attracts investors to invest in service sectors rather than production sectors by offering tax incentives. Trade reduces CO_2 emissions in Singapore, Thailand, and Vietnam while increase the emissions in long-run, whereas the opposite true in the case of Malaysia and Indonesia. The short-run impacts of trade, on the other hand, were not prevailing except in Indonesia and Thailand where CO_2 emission decreased as trade activities increased in both countries. Being one of the most trade-oriented regions in the world, trade is one of the critical components in the ASEAN economic development. Hence, policy makers in ASEAN should impose regulations to effectively reduce the pollutions from which trade activities induced in order to prevent this region becoming a pollution haven. Potential strategies are increasing tax on manufacturers who produce excessive CO_2 emissions by forcing them to shift to less polluting material or increase tariffs if necessary, even though it may not be ideal.

To wrap up this study with some final remarks for the limitation and suggestion for future studies. First, this paper only focused on testing the validity of EKC hypothesis in six ASEAN nations, causality test was not performed to further investigating the possible causations between the selected variables due to time constraint. Furthermore, many literatures on testing EKC hypothesis have shifted to study the impacts of energy sources, specifically in the effects from the utilization of renewable and non-renewable energy on environmental degradation and economic growth. Last but not the least, there are not many existing literatures available regarding the impacts of FDI and trade on the environmental quality in ASEAN countries. Future studies may focus on examining the grand economic initiative of China- “One Belt One Road”, which some ASEAN countries had already signed or shown interests to be part of the partnership. As ASEAN’s third largest trading partner, the potential environment impacts in this region due to the cooperation with China’s new economic initiative have yet to be fully explored.

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