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Article

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The Impact of Energy Consumption based on Fossil Fuel and Hydroelectricity Generation towards Pollution in Malaysia, Indonesia and Thailand

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ABSTRACT

This study investigated the effects of energy consumption (ENY) based on fossil fuels and alternative energy with hydroelectricity as its proxy upon pollution, aside from ascertaining if the correlation between income and pollution determined the presence of Environmental Kuznets curve (EKC). In addition, the functions of foreign direct investment (FDI) inflows and trade openness (TO) were probed into so as to generate more precise outcomes of EKC hypothesis. Hence, in order to fulfil the objectives outlined in this study, the Bound estimation method was utilized to examine three developing nations of the Association of South East Asian Nation (ASEAN), which are Malaysia, Indonesia, and Thailand. The main finding of interest retrieved from this paper refers to the EKC hypothesis reflective of Malaysia and Thailand. It was discovered that hydroelectricity favourably lowered the release of carbon emissions in the case of Malaysia, while it insignificantly influenced environmental degradation for Indonesia and Thailand. On the other hand, as anticipated, per capita energy use displayed a significant long-run effect in raising the levels of carbon emission in Indonesia and Thailand. Meanwhile, the FDI inflows seemed to improve the environmental quality only in Malaysia, while deepening in TO among ASEAN-3 nations appeared to successfully minimize issues related to environmental degradation in these countries.

Keywords: Energy Consumption, Hydroelectricity, Real Output, Carbon Emissions
JEL Classifications: O1, Q2, Q4

1. INTRODUCTION

The deleterious effects of global warming have begun to affect the human race due to the changes noted in the global climate, for instance, acceleration in rising of sea level (Yi et al., 2017) and increment in risks of wildfires (Kalabokidis et al., 2015). In fact, the global climate system appears to be unambiguously warm with the rising temperature at approximately 0.85 (0.65°C-1.06°C) from 1880 to 2012, as reported by the Intergovernmental Panel on Climate Change (IPCC) (2013). The climate change can negatively influence the environment ecosystem and the sustainability of socio-economic (Enríquez-de-Salamanca et al., 2017; Zhang et al., 2017). The most significant driver of climate change is the larger emission of Greenhouse Gases (GHG) being released into the atmosphere. The GHG reabsorbs infrared radiation and heat that is penetrated from the sun to the earth. As such, GHG prevents the heat escaping from the earth, thus causing the earth to become warmer; a phenomenon known as the greenhouse effect. Since year 1750, the concentration of essential elements that make up GHG in the atmospheres, which are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), has been reported to rise by approximately 144%, 256%, and 121%, respectively. Nonetheless, the World Meteorological Organization (WMO) (2016) reported that the concentration of these elements for year 2015 appears to be approximately 400.0 ± 0.1 ppm (CO_2), 1845 ± 2 ppb (CH_4), and 328.0 ± 0.1 ppb (N_2O).

The energy sector, especially the oil and coal-based fuel, has contributed predominantly to the massive emission of GHGs into the atmosphere (Bhanu et al., 2018). Coal and fossil fuel are popular, particularly among developing countries for it is one of the cheapest sources of energy, in comparison to other sources. In addition, the International Energy Agency (IEA) has reported that the Southeast Asia is one of the few regions in the world that has an increasing share of coal in its energy mix (IEA, 2015). On top of that, fossil fuel and coal have remained the larger contributor for electric generation in Association of South East Asian Nation (ASEAN)-3 countries, as reported by Suruhanjaya Tenaga (ST) (2016) for Malaysia, Dewan Energi Nasional (DEN) (2016) for Indonesia, and Electricity Generating Authority of Thailand (EGAT) (2016) for Thailand.

In fact, numerous energy resources are available that are cleaner than fossil fuel and coal; in which hydroelectricity is one of them, which has been considered as one of the most environmental-friendly energy forms (Tampakis et al., 2013; Melikoglu, 2017). Hydroelectric energy has the potential to decrease GHG emission into the atmosphere, as hydro plant is free from air pollution. Moreover, the source of energy itself derives from natural resource; kinetic energy from the flow of river water. In comparison to other intermittent renewable energy resources, such as wind and solar energy, hydroelectric energy appears to be the best alternative energy that can compete with fossil fuel to generate huge volumes of electricity. According to the Renewable Energy Policy Network for the 21th Century (REN21) in year 2017, Thailand had set the highest target on hydropower at a capacity of 6.1 GW to achieve by 2021. While in Indonesia, the target capacities of hydropower and mini-hydro by 2021 are 2.1 GW and 0.43 GW, respectively. As for Malaysia, the target for micro-hydro is 2.1 GW of generation capacity. Nevertheless, a recent report published by the International Hydropower Association (IHA) (2018) states that the present installed capacity of large hydropower in Malaysia seem to be the highest among the three nations (6.094 GW), followed by Indonesia (5.305 GW), and Thailand (4.51 GW).

Koutroumanidis et al. (2009) revealed that energy resource is the dominant factor for the growth of socio-economic in any nation. In fact, this notion is in agreement with Stern (2011) as he found that the emerging and industrialized economies are driven by both economic and better quality of energy inputs. Conversely, the Asian Development Bank (ADB) (2016) highlighted that climate change is putting pressure on food security and causing a negative effect on the well-being of humans. Moreover, the demand for total primary energy among Southeast Asia nations has been projected to escalate by 80% from year 2013 until 2040 mainly due to increment of economic activities within the region by triple and hike in shifts among the populations to urban areas for better employment and lifestyle. Besides, vast industrial and commercial facilities are available in urban areas due to increment in population, thus contributing to the rising energy consumption and demand IEA (2015) also reported that Indonesia has the largest EN, followed by Thailand and Malaysia.

As such, this study investigated the effect of energy based on fossil fuels and alternative energy with hydroelectricity as its proxy upon pollution among selected three ASEAN countries, which are Indonesia, Malaysia, and Thailand, over a period ranging from 1980 and 2014. Furthermore, to shed light on the correlation between growth and rate of pollution among these nations, this paper probed into the presence of Environmental Kuznets curve (EKC) hypothesis.

The EKC assumes that environmental degradation first increases as income increases during the earlier stage of economic development and then when income reaches a certain high level, the level of pollution starts to decreases. Although this issue has been studied by Adebola et al. (2017) and Jebli et al. (2016), this paper offers a new view, in which cleaner energy via hydroelectricity is introduced as one of the variables to determine the existence of EKC. Hence, this paper appears to be a potential study that adds value to the existing literature, especially from the lens of ASEAN countries. The remaining sections of the paper are organized as follows: Section 2 reviews the relevant literature on several variables related to energy and the methodology associated to EKC hypothesis. Next, Section 3 highlights the sources of data and briefly explains the empirical methodology applied in the study. After that, Section 4 presents the empirical results and discussion. Finally, the paper ends with Section 5, where the conclusion and several policy recommendations are depicted.

2. LITERATURE REVIEW

The existence of EKC hypothesis has been a subject of interest among many researchers over the years. Given that the theme of this paper revolves around validation of EKC hypothesis and source of energy (ENY), only papers that have utilized both gross domestic product (GDP) and square of GDP (GDP^2), as well as all the types of energy sources tabulated in Table 1, have been considered.

Overall, this area of study has varied spheres. The past literature has employed a number of determinants to determine pollutions, for example, real output (GDP), energy consumption (ENY), industrial output, urbanization, population, financial development, trade openness (TO), and foreign direct investment (FDI). Next, some researchers have applied various indicators to identify pollution in many nations across regions, namely East Asia and Pacific (cf. Saboori and Sulaiman, 2013; Chandran and Tang, 2013), Europe and Central Asia (cf. Acaravci and Ozturk, 2010; Pao et al., 2010; 2011; Kasman and Duman, 2015), Middle East and North Africa (cf. Arouri et al., 2012; Ozcan, 2013; Shahbaz et al., 2014), South Asia (cf. Shahbaz et al., 2012), and Sub-Saharan Africa (cf. Kivyiro and Arminen, 2014; Shahbaz et al., 2015). Third, some studies opted to use GDP solely to account for the presence of EKC hypothesis. Nevertheless, in order to gain better and accurate results of the inverted EKC hypothesis, GDP and GDP^2 should be incorporated as indicators for pollution.

Table 1: Summary of EKC hypothesis and variables used for energy from 2010-2018

Authors	Country	Period	Variable for energy	Methodology	EKC hypothesis
Acaravci and Ozturk (2010)	European countries	1960-2005	Energy consumption	ARDL and VECM granger causality	Yes
Pao and Tsai (2010)	Brazil, Russia, India and China	1971-2005	Energy consumption	Pedroni, Kao and Johansen cointegration, ordinary least square and VECM granger causality	Yes
Pao and Tsai (2011)	BRIC countries	1980-2007	Energy consumption	Pedroni, Kao and Johansen cointegration, OLS and VECM granger causality	Yes
Pao and Tsai (2011)	Brazil	1980-2007	Energy consumption	Grey prediction model	Yes
Wang et al. (2011)	China	1995-2007	Energy consumption	Pedroni cointegration and VECM granger causality	No
Arouri et al. (2012)	Middle East and North African countries	1981-2005	Energy consumption	The cross correlated effects and CCE mean group	Yes
Jayanthakumaran et al. (2012)	China and India	1971-2007	Energy consumption	ARDL	Yes
Pao et al. (2012)	China	1980-2009	Energy consumption	Grey prediction model	No
Chandran and Tang (2013)	ASEAN	1971-2008	Transport energy consumption	Johansen cointegration and VECM granger causality	No
Govindaraju and Tang (2013)	India and China	1965-2009	Coal consumption	Bayer and Hanck combine cointegration test, and VECM granger causality	No
Kohler (2013)	South Africa	1960-2009	Energy consumption	ARDL, Johansen cointegration and VECM granger causality	Yes
Ozcan (2013)	Middle east countries	1990-2008	Energy consumption	Westerlund panel cointegration, Full modified OLS and VECM granger causality	Yes
Saboori and Sulaiman (2013a)	ASEAN countries	1971-2009	Energy consumption	ARDL, Johansen cointegration and VECM granger causality	Yes, for Thailand and Singapore
Saboori and Sulaiman (2013b)	Malaysia	1980-2009	Electricity consumption, oil consumption, coal consumption and gas consumption	ARDL, Johansen cointegration and VECM granger causality	Yes
Shahbaz et al. (2013a)	Africa	1965-2008	Coal consumption	ARDL, Johansen cointegration and VECM granger causality	Yes
Bella *et al*. (2014)	Organization for Economic Cooperation and Development (OECD) countries	1965-2006	Electricity consumption	Larsson, Lyhagen, and Lothgren cointegration and VECM granger causality	Yes
Farhani et al. (2014)	Tunisia	1971-2008	Energy consumption	ARDL, and VECM granger causality	Yes
Kivyiro and Arminen (2014)	Sub-Saharan countries	1971-2009	Energy consumption	ARDL, and VECM granger causality	Yes, in most countries
Saboori et al. (2014)	OPEC countries	1977-2008	Oil consumption	ARDL, and Toda-Yamamoto-Dolado-Lutkepohl causality	Yes
Al-Mulali et al. (2015)	Ninety-three countries based on income	1980-2008	Energy consumption	Panel fixed effects and the generalized method of moments	Yes, for upper and high income countries
Al-Mulali et al. (2015)	Vietnam	1981-2011	Renewable energy consumption	ARDL, and VECM granger causality	No
Baek (2015)	Artic countries	1960-2010	Energy consumption	ARDL	Yes
Baek (2015)	Nuclear producing countries	1980-2009	Nuclear energy consumption and energy consumption	Pedroni cointegration, DOLS and FMOLS	Yes
Begum et al. (2015)	Malaysia	1970-2009	Energy consumption	ARDL, DOLS and Sasabuchi-Lind-Mehlum tests	Yes
Kasman and Duman (2015)	European Union (EU) countries	1992-2010	Energy consumption	Pedroni and Kao cointegration, FMOLS, and VECM granger causality	Yes
Ozturk and Al-mulali (2015)	Cambodia	1996-2012	Energy consumption	Two-stage least square and GMM	No

(*Contd...*)

Table 1: (*Continued*)

Authors	Country	Period	Variable for energy	Methodology	EKC hypothesis
Shahbaz et al. (2015)	African countries	1980-2012	Electricity intensities	Johansen cointegration, Pedroni cointegration, and VECM granger causality	Yes
Tang and Tan (2015)	Vietnam	1976-2006	Energy consumption	Johansen cointegration, and VECM granger causality	Yes
Yin et al. (2015)	China	1976-2006	Renewable energy consumption	Panel random effects model	Yes
Jebli et al. (2016)	OECD countries	1980-2010	Renewable energy consumption and non-renewable energy consumption	Pedroni cointegration, FMOLS, DOLS and granger causality	Yes
Al-Mulali et al. (2016)	Countries in 7 regions	1980-2010	Renewable energy consumption	Pedroni and Fisher panel cointegration, DOLS and VECM granger causality	Yes, for East Asia and the Pacific, Western Europe, East Europe and Central Asia and The America
Shahbaz et al. (2016)	African countries	1971-2012	Energy intensities	ARDL, Bayer and Hanck cointegration	Yes, for Africa, Algeria, Cameroon, Congo Republic, Morocco, Tunisia and Zambia
Danish et al. (2017)	Pakistan	1970-2012	Renewable energy consumption and non-renewable energy consumption	ARDL, FMOLS, DOLS, and canonical cointegration	Yes
Dong et al. (2017)	30 provinces in China	1995-2014	Energy and Natural gas consumption	Panel FMOSL, panel DOLS	Yes
Kharbach and Chfadi (2017)	Morocco	2000-2011	Energy consumption and diesel consumption	Johansen cointegration	Yes
Adebola et al. (2017)	India and China	1965-2013	Hydroelectricity used per capita	ARDL, and VECM granger causality	Yes
Pal and Mitra (2017)	India and China	1971-2012	Electricity generated from coal as share of total electricity	ARDL	Yes
Shahbaz et al. (2017)	US	1960-2016	Biomass energy consumption	ARDL, and VECM granger causality	Yes
Sinha and Shahbaz (2018)	India	1971-2015	Renewable energy generation	ARDL	Yes
Adu and Denkyirah (2018)	West Africa countries	1970-2013	Combustible renewable Waste	Panel fixed and random effect	No

Referring to the list of studies presented in Table 1, 80% of the studies have accounted for the presence of EKC hypothesis by embedding income and pollution. The studies that involved high income nations, especially the Europe, did validate the presence of EKC (cf. Acaravci and Ozturk, 2010; Kasman and Duman, 2015), while contradicting results were found in most underdeveloped countries (cf. Al-Mulali et al., 2015; Ozturk and Al-mulali, 2015).

This study offers to bridge the existing gap of study concerning EKC hypothesis. First, this study contributes to the study of EKC hypothesis within the region of ASEAN-3 nations, namely Indonesia and Thailand, which have experienced rapid economy growth since the last three decades. Second, although the studies mostly used source of ENY and fossil fuels, none has included the aspect of alternative energy, such as hydroelectricity. Electricity generated from hydroelectricity has been used in these countries since the past four decades; however, it appears that the econometric model has yet to be applied. Therefore, this study examined the EKC hypothesis in Malaysia, Thailand, and Indonesia by including both types of energy. Third, prior studies outcomes may be inaccurate as a result of multicollinearity issue due to the inclusion of both GDP and GDP^2 within a regression. Thus, in the attempt to address this problem, this study adhered to the steps taken by Narayan and Narayan (2010), which is explained in the analysis section.

3. METHODOLOGY

Initially, the model of environmental quality was developed by presenting it in a broad format of EKC hypothesis, which can be translated in the following equation:

$$CO_2 = f(GDP, GDP^2) \quad (1)$$

where CO_2 refers to carbon emissions per capita proxy for pollution or level of environmental quality, *GDP* represents economic growth, while GDP^2 denotes the square of *GDP*. Economic growth is achieved when a nation has the ability to meet the demands of goods and services across a certain time period. This is determined by examining the variance of *GDP* between the target year and the previous year. The equation is transformed from 1 to log-linear specification (LN) because it can yield better and more accountable empirical outcomes, in comparison to the alternative method of simple linear modelling (Shahbaz et al., 2015), apart from allowing the value to convert to elasticities. Thus, the logarithm form for the estimation model is formulated as follows:

$$LNCO_{2t} = \alpha_0 + \alpha_1 LNGDP_t + \alpha_2 (LNGDP_t)^2 + \varepsilon_t \quad (2)$$

where t refers to time period, CO_2 represents carbon emissions per capita, *GDP* denotes per capita real *GDP*, and ε is standard error term. The variance of the functional forms between the variables of economic growth and carbon emissions is portrayed in the values of income coefficients. When the result shows $\alpha_1=\alpha_2= 0$, a level relationship is concluded, $\alpha_1 < 0$ and $\alpha_2 = 0$ display the evidence of monotonically decreasing linear relationship, $\alpha_1 > 0$ and $\alpha_2 = 0$ account for the presence of a monotonically increasing linear relationship, $\alpha_1 < 0$ and $\alpha_2 > 0$ yield the evidence for U-shaped relationship, and $\alpha_2 < 0$ portrays an inverted U-shaped relationship, which accounts for EKC in relation to carbon emissions. In another instance, Saboori et al. (2012) tested the EKC hypothesis by excluding other explanatory variable, as displayed in equation 2. Nonetheless, the study concluded that the outcome of EKC that appeared to exist in the estimated model was insufficient to ascertain the presence of inverted-U relationship between environmental degradation and income.

Based on these findings, alternatives for significant variables are proposed so as to exert influence pertaining to the presence of EKC hypothesis in the model. An example of it is ENY, which has been widely used in prior environmental quality models based on studies carried out by Hossain (2011), Pao and Tsai (2011), Al Mulali and Che Sab (2012), as well as Saboori and Sulaiman (2013a,b), which considered ENY as a vital determinant of carbon emissions. From the perspectives of ASEAN-3 developing nations (Malaysia, Indonesia, and Thailand), these countries heavily rely on dirty energy, such as coal, to stimulate economic activities mainly because the cost of using such energy is relatively cheaper. In precise, fossil fuel combustions that yield higher ENY would end up causing extensive damages due to higher release of carbon emissions that contributes to the degradation of environmental quality. In response to more call for alternative energy sources that stems from the awareness of climate change, these countries have begun utilising other cleaner sources, such as hydroelectricity, as a substitute for fossil-type energy resources. Studies that have depicted the use of hydroelectricity using the model are carried out by Solarin et al. (2017) on India and China. Thus, the study embedded hydroelectricity as a proxy for alternative ENY in the model. The new equation is given as follows:

$$LNCO_{2t} = \alpha_0 + \alpha_1 LNGDP_t + \alpha_2 (LNGDP_t)^2 + \alpha_3 LNENY_t + \alpha_4 LNAENY_t + \varepsilon_t \quad (3)$$

Next, a study conducted by Lau et al. (2014) revealed an increased dependency on FDI for growth among developing countries in ASEAN. Nevertheless, the inflows of FDI in these countries may have an adverse effect upon environmental quality. Thus, similar to the prior model proposed by Al-Mulali (2012) and Pao and Tsai (2011), the FDI had been incorporated in this study as a crucial determinant of carbon emissions. In other instances, Jensen (2006) and Acharyya (2009) concluded that FDI can have a double-edged sword effect; which means, it facilitates economic growth, but at the same time, causes serious implication towards the environment through industrial pollution and environmental degradation. Moreover, in order to cut cost on environmental controls, the underdeveloped regions become the safe haven for these polluting industries and businesses as these regions have a more relaxed attitude towards environmental standards, thus turning into pollution slums; described as Pollution Haven Hypothesis (PHH). Meanwhile, under the Halo Effect Hypothesis (HEH), more efficient and cleaner production technology that commonly derives from advanced countries is adopted as a result of FDI so as to enhance the environmental quality (Stretesky and Lynch, 2008). Hence, the new equation is stated as follows:

$$LNCO_{2t} = \alpha_0 + \alpha_1 LNGDP_t + \alpha_2 (LNGDP_t)^2 + \alpha_3 LNENY_t + \alpha_4 LNAENY_t + \alpha_5 LNFDI_t + \varepsilon_t \quad (4)$$

From equation 4, the next variable that can generate a juxtaposition effect upon the level of environmental quality (CO_2) is TO. In fact, many studies have employed TO as a determinant for carbon emissions, for example, Halicioglu (2009) for Turkey, and Tiwari et al. (2013) for India. According to Copeland and Taylor (2004) and Baek et al. (2009), globalization may be the leading cause of the rising active pollution from intensive industries among the developing nations in ASEAN, which have severely affected the quality of the environment. This implies that prior studies that have omitted trade-related variables, such as FDI and TO, may portray a hint of biasness. The new equation is listed in the following:

$$LNCO_{2t} = \alpha_0 + \alpha_1 LNGDP_t + \alpha_2 (LNGDP_t)^2 + \alpha_3 LNENY_t + \alpha_4 LNAENY_t + \alpha_5 LNFDI_t + \alpha_6 LNTO_t + \varepsilon_t \quad (5)$$

where α denotes regression coefficient, while α_1, and α_3, are predicted to display positive sign. Nonetheless, either positive or negative sign can be expected for α_2, α_4, α_5 and α_6. Finally, μ refers to error term that is assumed to be normally distributed with zero mean and constant variance. In fact, the empirical model employed in this study incorporated most of the vital determinants for carbon emissions, thus clearing this study from any concern associated to variable bias, primarily because all the variables were regressed within the same multivariate framework. Furthermore, by employing the unrestricted version of Autoregressive Distributed Lag (ARDL) model initiated by Pesaran et al. (2001), this study formulated the following error correction models based on equation 5:

$$\Delta LNCO_{2t} = \beta_0 + \theta_0 LNCO_{2t-1} + \theta_1 LNGDP_{t-1} + \theta_2 LNGDP^2{}_{t-1} + \theta_3 LNENY_{t-1} + \theta_4 LNAENY_{t-1} + \theta_5 LNFDI_{t-1} + \theta_6 LNTO_{t-1} + \sum_{i=1}^{a} \beta_i \Delta LNCO_{2t-i} + \sum_{i=0}^{b} \gamma_i \Delta LNGDP_{t-i} + \sum_{i=0}^{c} \delta_i \Delta LNGDP^2{}_{t-i} + \sum_{i=0}^{d} \lambda_i \Delta LNENY_{t-i} + \sum_{i=0}^{e} \vartheta_i \Delta LNAENY_{t-i} + \sum_{i=0}^{f} \psi_i \Delta LNFDI_{t-i} + \sum_{i=0}^{g} \rho_i \Delta LNTO_{t-i} + \upsilon_t \quad (6)$$

where Δ represents the first difference operator and u_t refers to white-noise disturbance term. Besides, the residuals for unrestricted error correction model (UECM) should be serially uncorrelated, and the model has to be stable. Meanwhile, the null hypothesis of no co-integration against the alternative hypothesis for the presence of long-run co-integration is defined by the following:

H_0: $\theta_0 = \theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = \theta_6 = 0$ (absence of long-run relationship)

H_1: $\theta_0 \neq \theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4 \neq \theta_5 \neq \theta_6 \neq 0$ (presence of a long-run relationship).

Next, upon confirming the existence of long-run relationship via F statistic, both long-run and short-run elasticity coefficients can be determined.

The long-run relationship model is depicted in the following:

$$\Delta LNCO_{2t} = \beta_0 + \alpha_0 LNCO_{2t-1} + \alpha_1 LNGDP_{t-1} + \alpha_2 LNGDP^2{}_{t-1} + \alpha_3 LNENY_{t-1} + \alpha_4 LNAENY_{t-1} + \alpha_5 LNFDI_{t-1} + \alpha_6 LNTO_{t-1} + \upsilon_t \quad (7)$$

Next, the short-run relationship model is presented as follows:

$$\Delta LNCO_{2t} = \beta_0 + \varphi ECT_{t-1} + \sum_{i=1}^{a} \beta_i \Delta LNCO_{2t-i} + \sum_{i=0}^{b} \gamma_i \Delta LNGDP_{t-i} + \sum_{i=0}^{c} \delta_i \Delta LNGDP^2{}_{t-i} + \sum_{i=0}^{d} \lambda_{t-i} \Delta LNENY_{t-i} + \sum_{i=0}^{e} \vartheta_{t-i} \Delta LNAENY_{t-i} + \sum_{i=0}^{f} \psi_{i-1} \Delta LNFDI_{i-1} + \sum_{i=0}^{g} \rho_{i-1} \Delta LNTO_{i-1} + \upsilon_t \quad (8)$$

where φ represents coefficient of error correction term (*ECT*). The value of *ECT* must be significantly negative to reflect converges, apart from displaying the rate of speediness of all the variables towards equilibrium. The variable ECT_{t-1}, which is a lagged value of the estimated ordinary least square (*OLS*) residual (υ_t) from the long-run model, is given based on equation 7.0. Moreover, it is essential to ensure that the proposed model is absent from serial correlation, normality, and homoscedasticity issues by performing a diagnostic test.

3.1. Sources of Data

The annual data employed in this study are mostly in the form of per capita and are derived from 1980 until 2014. CO_2 emissions are in metric tons per capita, real GDP is in constant 2010 US dollar, ENY is based on per capita (kg of oil equivalent), alternative energy with hydroelectricity generation as its proxy is divided by the total population so as to incur billion kilowatt hours per capita, while FDI and TO are based on their ratios over GDP. All data used in this study were based on the World Development Indicator (2017) generated by World Bank, except for hydroelectricity generation that had been obtained from U.S Energy Information Administration (2015).

4. RESULTS AND ANALYSIS

4.1. Testing the Stationarity of Data

The analysis was initiated by testing the data with Dickey-Fuller (ADF) and Phillip Perron (PP) unit root tests, in which the outcomes are depicted in Table 2. For all these tests, the null hypothesis includes a unit root, whereas the alternative hypothesis has no unit root. Unit root tests were performed to determine the order of integration of each variable so as to identify the best method of time series analysis suitable for the proposed econometric model. The selection of lag for the ADF unit root test was set based on Schwarz Info Criterion (SIC), given a small number of observations carried out in this study. In addition, all unit roots were estimated at level and first difference.

Overall, the results showcased a mix stationarity of the variables at level, I(0), and at first difference, I(1). To further clarify, based on the Malaysian ADF unit root test outcomes at level, both LNAENY and LNFDI appeared to be stationary, I(0) at 10% and 1% level, respectively. On the other hand, based on PP test at level, LNFDI was found to be significant at 1% level at both intercept and trend, and intercept. Nevertheless, at first difference for the ADF test, these variables seemed to be insignificant at trend and intercept for LNAENY, but both intercept and trend, and intercept for LNFDI. A more powerful property of unit root, which is the PP test, was performed and exhibited that all variables were significant mostly at 1% level. The mixed evidence for stationarity of the variables at level and at first difference was also determined for Indonesia and Thailand. Thus, the mixed stationarity of the unit roots favoured the condition for implementation of ARDL estimation for all the three countries.

4.2. Determining Long-run Relationship

In order to confirm the presence of long-run relationship between the variables, the model of each ASEAN-3 had been tested by using ARDL co-integration test, which revealed the F-statistic values, as tabulated in Table 3. The null hypothesis cannot be rejected if the F-statistic falls below the bound level, but if the F-statistic exceeds the upper bound level; the null hypothesis is rejected, thus signifying the existence of co-integration. The results showed that the null hypothesis of no co-integration for Malaysia (4.14 > 3.61) is rejected at 5% significant level, while Indonesia (7.00 > 4.43) and Thailand (8.93 > 4.43) are rejected at 1% level, given that their F-statistic values were greater than the upper bound critical value, I(1), as given in Table 3. This implies a tendency for the variables to move towards the long-run equilibrium for all the proposed models.

Table 2: Results of ADF and PP unit root tests

Country	Variable	ADF unit root test		PP unit root test	
		Intercept	Trend and intercept	Intercept	Trend and intercept
Malaysia					
Level	$LNCO_2$	−1.25 (0)	−1.57 (0)	−1.28 (1)	−1.61 (2)
	LNGDP	−0.66 (0)	−1.69 (0)	−0.66 (1)	−1.87 (2)
	$LNGDP^2$	−0.49 (0)	−1.83 (0)	−0.50 (1)	−2.01 (2)
	LNENY	−1.14 (0)	−1.73 (0)	−1.32 (5)	−1.70 (1)
	LNAENY	−2.76 (1)*	−3.11 (1)	−2.05 (16)	−2.17 (11)
	LNFDI	−4.93 (0)***	−4.98 (0)***	−4.93 (0)***	−4.99 (1)***
	LNTO	−1.56 (1)	0.42 (0)	−1.34 (3)	0.13 (1)
First difference	$LNCO_2$	−6.46 (0)***	−6.49 (0)***	−6.42 (2)***	−6.46 (2)***
	LNGDP	−4.81 (0)***	−4.74 (0)***	−4.81 (0)***	−4.74 (0)***
	$LNGDP^2$	−4.89 (0)***	−4.81 (0)***	−4.89 (0)***	−4.81 (0)***
	LNENY	−6.28 (0)***	−6.32 (0)***	−6.39 (3)***	−6.82 (6)***
	LNAENY	−5.07 (1)***	−3.09 (3)	−4.48 (15)***	−4.34 (15)***
	LNFDI	−1.63 (7)	−1.84 (7)	−24.13 (22)***	−23.16 (23)***
	LNTO	−3.41 (0)**	−3.48 (2)*	−3.44 (5)**	−3.75 (15)**
Indonesia Level					
	$LNCO_2$	−1.08 (0)	−3.15 (0)	−1.00 (6)	−2.88 (5)
	LNGDP	0.02 (0)	−2.21 (1)	0.02 (0)	−1.92 (2)
	$LNGDP^2$	0.25 (0)	−2.19 (1)	0.25 (0)	−1.86 (2)
	LNENY	−1.28 (0)	−1.10 (0)	−1.35 (5)	−1.07 (1)
	LNAENY	−2.39 (2)	−3.69 (0)**	−2.42 (4)	−3.68 (4)**
	LNFDI	−2.66 (0)*	−4.29 (1)***	−2.44 (15)	−3.46 (15)*
	LNTO	−2.94 (0)*	−2.91 (0)	−2.96 (3)**	−2.94 (3)
First difference	$LNCO_2$	−5.57 (1)***	−5.43 (1)***	−6.67 (10)***	−6.43 (9)***
	LNGDP	−4.39 (0)***	−4.35 (0)***	−4.42 (1)***	−4.35 (2)***
	$LNGDP^2$	−4.34 (0)***	−4.34 (0)***	−4.37 (1)***	−4.33 (2)***
	LNENY	−5.91 (0)***	−3.97 (7)**	−5.91 (1)***	−6.08 (5)***
	LNAENY	−7.39 (1)***	−7.70 (1)***	−10.50 (4)***	−10.73 (3)***
	LNFDI	−6.76 (2)***	−6.64 (2)***	−9.00 (11)***	−8.77 (11)***
Thailand Level	LNTO	−8.35 (0)***	−8.24 (0)***	−8.35 (0)***	−8.24 (0)***
	$LNCO_2$	−1.27 (0)	−0.48 (0)	−1.15 (2)	−0.86 (2)
	LNGDP	−1.51 (1)	−1.73 (1)	−1.47 (2)	−1.33 (3)
	$LNGDP^2$	−1.36 (1)	−1.82 (1)	−1.26 (2)	−1.45 (3)
	LNENY	−0.51 (0)	−1.30 (0)	−0.54 (3)	−1.75 (3)
	LNAENY	−3.88 (1)***	−4.86 (1)***	−5.73 (6)***	−12.38 (33)***
	LNFDI	−2.89 (0)*	−3.26 (0)*	−2.81 (3)*	−3.34 (3)*
	LNTO	−0.85 (0)	−1.61 (0)	−0.86 (1)	−1.87 (3)
First difference	$LNCO_2$	−3.89 (0)***	−4.24 (0)**	−3.88 (1)***	−4.26 (6)***
	LNGDP	−3.15 (0)**	−3.34 (0)*	−3.15 (0)**	−3.36 (1)*
	$LNGDP^2$	−3.31 (0)**	−3.43 (0)*	−3.31 (0)**	−3.44 (1)*
	LNENY	−4.37 (0)***	−4.32 (0)***	−4.32 (2)***	−4.25 (2)**
	LNAENY	−5.89 (3)***	−6.10 (3)***	−12.40 (27)***	−15.85 (23)***
	LNFDI	−7.86 (0)***	−7.83 (0)***	−8.16 (2)***	−8.78 (4)***
	LNTO	−5.50 (0)***	−5.47 (0)***	−5.50 (1)***	−5.46 (1)***

(1) ***, **, and *are 1%, 5%, and 10% of significant levels, respectively. (2) The optimal lag length was selected automatically by using the SIC for ADF test, while the bandwidth was opted by using the Newey–West method for the PP test. (3) Number in parentheses refers to standard errors

Table 3: Results of ARDL co-integration

ASEAN-3	Maximum lag	SIC (a, b, c, d, e, f, g)	F Statistic at SIC	Result
Malaysia	(4,2)	(1,2,2,0,0,1,2)	4.14**	Co-integration exists
Indonesia	(2,2)	(2,0,0,2,1,0,2)	7.00***	Co-integration exists
Thailand	(3,3)	(1,1,3,3,2,3,2)	8.93***	Co-integration exists
Critical values for F-statistics#			Lower I (0)	Upper I (1)
1%			3.15	4.43
5%			2.45	3.61
10%			2.12	3.23

#The critical values were obtained from Pesaran et al. (2001) based on case III: unrestricted intercept and no trend. *, **, and ***represent 10%, 5%, and 1% level of significance, respectively

4.3. Diagnostic Test

Table 4 presents the outcomes of diagnostic statistics, such as serial correlation test, misspecification test, heteroscedasticity test, and normality test. All the tested models for the countries selected in this study seemed to be absent from any diagnostic test, given that the probability values are >10% significant level.

Therefore, the outcomes produced from all the three models are indeed reliable. Besides, the size of the adjusted R^2 indicated a good fit for all the models.

Apart from diagnostic tests, it is compulsory to determine the stability of each model via Cumulative Sum of Recursive Residual (CUSUM) and Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ) stability tests. The diagrams illustrated in Table 5 show that the plots of both CUSUM and CUSUMSQ, as represented by blue line, appear to fall inside the critical bounds of 5% significant level for all ASEAN-3 countries, except for CUSUMSQ of Indonesia. The plot of CUSUMSQ for Indonesia seemed to be out of the critical limits, hence suggesting some instability in the model. Nevertheless, as the plot returned towards the critical bands, the deviation was only transitory. Furthermore, the outcomes of stability tests for Malaysia, Indonesia, and Thailand suggest that policy changes, upon considering the explanatory variables of carbon emissions embedded in this study, did not cause any major distortion in the level of carbon emissions.

4.4. The Long-run Elasticities

The outcomes of long-run elasticities, as displayed in Table 6, are briefly explained in this section.

4.4.1 Malaysia

Based on the estimation of long-run elasticities, this study validated the EKC hypothesis, given that Malaysia's both GDP and GDP^2 have the correct expected sign and are significant at 1% level. Furthermore, the use of varying sets of determinants in this study, as opposed to prior studies conducted by Saboori et al. (2012), Saboori and Sulaiman (2013b), Lau et al. (2014), and Begum et al. (2015), aids in contributing in-depth knowledge on this scope. The presence of EKC hypothesis, which is also known as inverted U-shaped relationship between economic growth and environmental quality with CO_2 emissions as the proxy, displayed that through the period of observation, Malaysia took several active measures in minimizing pollution by joining in the efforts that protect the environment, namely Kyoto Protocol that aims to put a stop to greenhouse effect. Aside from that, Malaysia is also

Table 4: Results of diagnostic test

ASEAN-3	Serial correlation $X^2(1)$ [P-value]	Functional form $X^2(1)$ [P-value]	Normality $X^2(2)$ [P-value]	Heteroscedasticity $X^2(1)$ [P-value]	Adjusted R^2
Malaysia	0.38 [0.68]	1.14 [0.29]	0.05 [0.97]	1.43 [0.23]	0.98
Indonesia	1.01 [0.38]	2.48 [0.11]	0.91 [0.63]	1.51 [0.19]	0.97
Thailand	1.77 [0.22]	0.55 [0.47]	0.35 [0.83]	0.89 [0.60]	0.99

The numbers in brackets [ ] refer to P values

Table 5: Stability tests

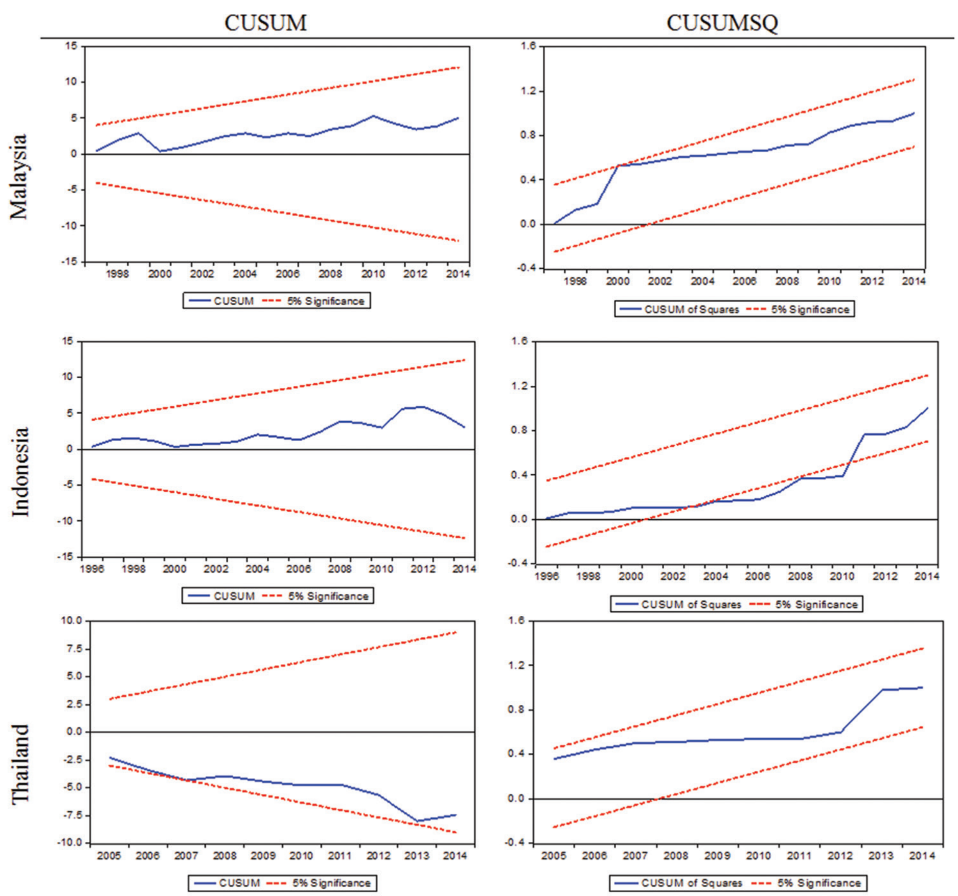

Table 6: Estimation of long-run elasticities

Country/ARDL	Malaysia (1,2,2,0,0,1,2)	Indonesia (2,0,0,2,1,0,2)	Thailand (1,1,3,3,2,3,2)
LNGDP	28.36*** (4.27)	−9.46*** (2.52)	10.04*** (1.25)
$LNGDP^2$	−1.54*** (0.242)	0.61*** (0.15)	−0.76*** (0.10)
LNENY	0.06 (0.22)	1.30*** (0.28)	4.29*** (1.03)
LNAENY	−0.15*** (0.04)	0.04 (0.06)	−0.04 (0.52)
LNFDI	−0.03* (0.01)	0.02 (0.03)	0.09 (0.08)
LNTO	−0.57*** (0.14)	−0.29** (0.13)	−1.67** (0.67)
Constant	−127.62*** (18.43)	29.84*** (9.72)	−53.12*** (6.44)

Dependent variable is$\Delta LNCO_2$.*,**,*** indicate significance at 10%, 5%, and 1% significant level, respectively. Numbers in brackets represent standard error. The ARDL estimation outcomes were generated by using SIC

associated to millennium development goal (MDG) that assists in overcoming environmental degradation through enforcement of stringent environmental laws, such as Environmental Quality Act 1974 and Environmental Quality Order 1987, while simultaneously boosting its economic development. Next, alternative energy consumption (AENY) with hydroelectricity as its proxy resulted in a significantly negative sign at 1%. This means; 1% increment in hydroelectricity consumption could help to decrease 0.15% of carbon emissions, thus suggesting control of air pollution. This shows that the Malaysian government does not heavily depend on single source of energy alone, but also places focus on cleaner energy, which is in agreement with Ahmad et al. (2011). Besides AENY, both FDI and TO seemed to be significantly negative at 10% and 1%, respectively. The negative coefficient of FDI appears to be in line with the HEH, thus implying that higher FDI inflows have helped Malaysia with cleaner technology spill-over. On top of that, it was found that most multinational companies from Japan and Korea have adopted more advanced technology that focuses on cleaner energy, thus reducing reliance on dirty energy and controlling the release of carbon emissions. For instance, 1% increment in FDI led to 0.03% of decrease in carbon emissions. Embracing (TO) has helped to cut the level of carbon emissions in Malaysia, as 1% increment in TO decreases carbon emissions release by 0.57, which seems greater when compared to AENY and FDI. The negative sign of TO may imply that Malaysia has opted for more clean-intensive products for exports and has chosen to import pollution-intensive products from their trading partners. Besides, the government has been actively encouraging the local industries, particularly those involved in export activities, to select cleaner technologies over those obsolete and dirty. Lastly, ENY displayed a correct sign, which is positive, but it appears not to influence the level of carbon emissions in Malaysia, as it was insignificant at all levels. This result is opposed to the outcome of most prior studies conducted for Malaysia, such as that obtained by Shahbaz et al. (2013b).

4.4.2. Indonesia

As for the case in Indonesia, its economic progress has experienced the U-shaped EKC, following the negative and positive signs for GDP and GDP^2, respectively. Such results are in line with those retrieved from Lean and Smyth (2010) for Indonesia. This particular scenario reveals that the economic progress in Indonesia at both the initial and present stages has caused high environmental degradation. The Indonesian economic development is currently dealing with a rather critical environmental drawback, such as thinning of forests, water pollution due to dumping of industrial wastes into water, air pollution particularly in urban areas, and haze produced from forest fires. Among the notable environmental issue refers to the occurrence of massive and thick haze of smog caused by human activity, whereby land is burnt annually to make ways for the country to produce pulp, paper, and palm oil. This activity is most commonly done on the island of Sumatra located at the western Indonesia and Borneo, which does not only portray a negative impact upon climate change, but also causing a stir amongst its neighbouring countries, such as Malaysia and Singapore. Furthermore, the high reliance among Indonesian producers on dirty energy, which is based on fossil fuel type of energy, has led to higher environmental degradation. Thus, increase in ENY contributes to energy pollutants in a rather significant manner after economic growth. The results infer that a 1% rise in ENY is linked with a 1.30% increment in CO_2 emissions. Next, the outcome of TO was found to be negative and statistically significant at 5% level, which indicates that embracing TO has managed to decrease environmental degradation due to carbon emissions. This shows that TO offers access to Indonesia for advanced technology that emits less CO_2 emissions. Meanwhile, the alternative energy with hydroelectricity generation as its proxy (AENY) and FDI inflows failed to influence the level of environmental quality in Indonesia for they appeared insignificant at all levels.

4.4.3. Thailand

Similar to Malaysia, the validity of EKC hypothesis is also proven for the case of Thailand as both its GDP and GDP^2 displayed the correct expected sign and statistical significance at 1% level. The sustainable environmental quality, along with its progressive economic growth achieved by Thailand is believed due to the success of its 10^{th} and 11^{th} National Economic and Social Development Plan implemented from 2007 until 2016 by its government. The policies that emphasized on environmental governance, environmental quality promotions, environmental-friendly production and consumption, environmental responsibilities, as well as climate and natural disasters resilience, were specifically designed for the country to attain green and balanced growth. This outcome suggests a new empirical finding that supports the validity of EKC in Thailand, in comparison to all other past findings retrieved by Narayan and Narayan (2010) and Lean and Smyth (2010), who failed to support the validity of EKC for Thailand. Next, fossil fuel ENY appears to intensify pollution by its significantly positive effect upon carbon emissions. This particular outcome, in general, is in agreement with Saboori and Sulaiman (2013a,b), Shahbaz et al. (2014), and Cho et al. (2014). Briefly, 1% increment in ENY leads to a hike in carbon emissions by 4.29%. Besides, when compared to the outcomes derived from Indonesia, the magnitude for this variable seems greater for Thailand. Its AENY, on the other hand, displayed a negative impact upon pollution, but insignificant at all levels. Therefore, alternative energy has failed in becoming a key solution to decrease pollution. In addition, the findings of FDI and TO for Thailand are similar to those obtained for Indonesia, given that only TO displayed a significantly negative correlation with pollution or environmental quality. Along with other ASEAN nations (in this case, Malaysia and Thailand), trade liberalization has helped the country to be more particular with their export and import activities. Furthermore, in the attempt to support sustainable development goal (SDG) initiated by United Nation, Thailand and other ASEAN countries have begun implementing several effective strategies, such as imposing higher tax towards high pollution-intensive products and providing subsidies to its local producers who adopt cleaner technology. Thailand also may have comparative advantage in cleaner intensive product that promotes environmental quality. The outcomes further revealed that 1% increment in TO leads to 1.67% reduction in environmental degradation.

4.5. The Short-run Elasticities

The outcomes of short elasticities are as tabulated in Table 7. Narayan and Narayan (2010) suggested that a different method is required to determine if the tested countries have managed to reduce their CO_2 emissions over time with increment in their economic growth by comparing short-run with long-run elasticities. If the result shows smaller long-run income elasticity than that of short-run over a period of time, income is assumed to have contributed to less carbon emission. This appears to be a response to issues related to collinearity or multicollinearity that may exist between GDP and GDP^2.

Based on the significance at the same lag for GDP and GDP^2, it was discovered that in the short-run, the development in Malaysia resembled a U-shaped EKC, thus suggesting that development has results in greater environmental degradation. Similar scenario is reflected in Indonesia. Nevertheless, it was found that only Thailand validated the presence of EKC hypothesis and its size of magnitude seemed relatively greater in short-run, when compared to long-run. Thus, between the three ASEAN countries analysed in this paper, it can be concluded that only Thailand has managed to achieve sustainable economic development both for short-run and long-run, while sustainable economic development is only achieved by Malaysia in the long-run.

The size of magnitude for AENY for Malaysia seemed relatively greater in the short-run with a coefficient value of 0.19. This implies that the generation of hydroelectricity energy in Malaysia could effectively reduce carbon emission. Apart from AENY, TO (at lag 1) in Malaysia has also reduced the release of carbon emission. As for the case in Indonesia, increment in ENY has the ability to reduce carbon emission, while increased participation of Indonesia in international trade (TO) leads to worsening of air quality with a positive sign of TO. On the other hand, as for Thailand, higher ENY improves its environmental quality through lower release of carbon emissions, which is similar to the outcomes derived for Indonesia. Nevertheless, AENY displayed a positive sign, which means that the use of

Table 7: Estimation of short-run restricted error correction model

Variables	Malaysia	Indonesia	Thailand
$\Delta LNCO_2$	-	-	-
$\Delta LNCO_{2\text{-}1}$	-	0.77***	-
		(0.14)	
$\Delta LNCO_{2\text{-}2}$	-	-	-
$\Delta LNGDP$	18.52	−13.23***	26.98**
	(12.41)	(4.03)	(8.83)
$\Delta LNGDP_{-1}$	−31.76**	-	-
	(13.41)		
$\Delta LNGDP_{-2}$	-	-	-
$\Delta LNGDP^2$	−0.96	0.86***	−1.68***
	(0.70)	(0.25)	(0.53)
$\Delta LNGDP^2_{-1}$	1.83**	-	−0.06*
	(0.76)		(0.03)
$\Delta LNGDP^2_{-2}$	-	-	0.11***
			(0.02)
$\Delta LNENY$	0.07	0.13	1.91***
	(0.28)	(0.36)	(0.40)
$\Delta LNENY_{-1}$	-	−0.94**	0.04
		(0.06)	(0.23)
$\Delta LNENY_{-2}$	-	-	−1.42***
			(0.29)
$\Delta LNAENY$	−0.19***	−0.09	0.14**
	(0.06)	(0.06)	(0.04)
$\Delta LNAENY_{-1}$	-	-	0.11***
			(0.03)
$\Delta LNAENY_{-2}$	-	-	-
$\Delta LNFDI$	−0.02	0.04	0.03*
	(0.01)	(0.04)	(0.02)
$\Delta LNFDI_{-1}$	-	-	−0.01
			(0.01)
$\Delta LNFDI_{-2}$	-	-	−0.03
			(0.02)
$\Delta LNTO$	−0.28	0.27**	−0.62***
	(0.25)	(0.10)	(0.16)
$\Delta LNTO_{-1}$	0.56**	0.21**	0.41**
	(0.26)	(0.09)	(0.16)
$\Delta LNTO_{-2}$	-	-	-
ECT	−1.29***	−1.39***	−0.95***
	(0.23)	(0.00)	(0.29)

Dependent variable is$\Delta LNCO_2$. *,**, and *** indicate significance at 10%, 5%, and 1% significant level, respectively

hydroelectricity generation in short-run could cause greater pollution. On top of that, TO seemed to exhibit mixed expected signs on varied lags.

As depicted in Table 7, the estimated lagged ECT in ARDL regression for the three studied nations appear to be negative and statistically significant. Based on the ECT value, the highest speed of adjustment was obtained by Indonesia (−1.39), followed by Malaysia (−1.29), and Thailand (−0.95). As for Indonesia and Thailand, given their ECT value >−1, Narayan and Smyth (2006) suggested that instead of monotonically converging to the equilibrium path directly, the error correction process for these two countries fluctuates around the long-run value in a dampening manner. Nonetheless, once this process is complete, convergence to equilibrium path becomes rapid. For instance, more than 139%, 129%, and 95% of adjustments were completed within less than a year for both Malaysia and Indonesia, whereas a year for Thailand due to short-run adjustment, which is considered as very rapid.

5. CONCLUSION AND POLICY RECOMMENDATIONS

This paper has bridged the gap found in the literature pertaining to environmental economics studies within the context of selected ASEAN-3 nations regarding correlations between carbon emissions, economics growth, energy based on fossil fuel, alternative energy based on hydroelectricity generation, FDIs, and TO so as to generate a comparison between the emerging economies of Malaysia, Indonesia, and Thailand on the said terms. The study, hence, used annual time series data over the period of 1980 until 2014. The following conclusions are drawn from this exercise:

- All the models have passed the diagnostic test settings, i.e., normality test, stability tests, heterogeneity test, and stability tests, thus producing reliable outcomes.
- Overall, evidence for the existence of EKC hypothesis has been established for both the cases of Malaysia and Thailand. Relatively, economic growth in Indonesia appears to cause higher influence on carbon emissions and its policymakers should, therefore, pay more attention on this situation.
- The fossil fuel type of energy harms the environmental quality in Indonesia and Thailand, while insignificant impact of energy was discovered upon Malaysian environment.
- Hydroelectricity generation has successfully improved the environmental quality in Malaysia, but it has failed to influence carbon emissions level in Indonesia and Thailand.
- Higher FDI inflows may aid in decreasing issues related to environmental degradation in Malaysia, thus validating the HEH.
- Embracing TO has successfully improved environmental quality for all the studied ASEAN-3 countries.

Overall, the ASEAN-3 nations should devise effective strategies so as to ascertain the quality of sustainable environmental in their region. The strategies may consist the following:

- First, it is highly suggested that ASEAN-3 countries should initiate an economic model based on sustainable development goals. For example, Malaysia has made a commitment to reduce carbon emissions by 40% by 2020 and actively promoting green economy should be noted as a valuable lesson. Besides, intensifying green economy initiatives could allow decoupling economic growth and carbon emissions. However, proper implementation of these strategies is necessary so as to ensure the success of such initiatives. For example, the Malaysia government has introduced the Green Technology Master Plan 2017-2030 in the attempt to slash carbon emissions from the present eight metric tonnes (MT) per capita to six MT per capita in 2030. Based on the outcomes of this paper, Malaysia and Thailand could share their individual experiences on sustainable development practices to their neighbouring country, Indonesia.
- Generally, the policymakers of ASEAN-3 countries should develop a concreate policy framework that promotes long-term value to reduce GHG emissions, aside from constantly supporting the progress of new technologies that lead to less carbon-intensive economy.
- It is suggested for Indonesia and Thailand to increase the volume of investment by injecting more capital into projects that utilise alternative energy, as practiced in Malaysia. This strategy could cut the consumption of fossil fuels and facilitate the role of alternative energy, such as hydroelectricity, as highlighted in this research paper.
- Policymakers should impose stringent environmental laws, particularly regarding energy-intensive and polluted foreign industries. The design of new environmental policies that improve regularity framework and enforcement activity can also help to mitigate environmental damages, thus leading towards sustainability in environmental quality among these nations.
- Additionally, given the positive impact of trade towards environmental quality among the studied nations, it is advisable for these countries to maintain trade-related actions and strategies so as to heighten environmental protection, which is crucial to successfully lift environmental pressure induced by trade, in precise.

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