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Does Equitable Income Distribution Influence Environmental Quality? Evidence from Developing Countries of ASEAN-4

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ABSTRACT

This paper investigates income distribution-environment nexus in the context of country-specific time series data from four member states of the Association of South East Asian Nations (ASEAN-4), namely Malaysia, Indonesia, Philippines and Thailand. The short run and long run effects of income inequality, economic growth, domestic investment, trade openness and energy consumption on Carbon Dioxide (CO_2) emissions were examined by using Autoregressive Distributed Lag (ARDL) estimation. The annual data used in this study covers the period from 1971 to 2013. More equitable income distribution results in better environmental quality for Indonesia and Thailand but leads to a worsening environment in the case of Malaysia. Meanwhile, no significant relationship was detected between income distribution and environmental quality in Philippines. It was also found that domestic investment and energy consumption have beneficial effects on the environmental quality in Indonesia whereas trade openness and the expansion of the economy (GDP) will have a detrimental effect on its environment. However, these variables have shown mixed results in the case of Indonesia, Philippines and Thailand. The main contribution of this study is the introduction of income distribution as a new determinant for environmental quality for these ASEAN-4 countries, thus giving new insights for policymakers to propose better policy recommendations on achieving sustainable growth.

Keywords: Income distribution, environmental quality, ASEAN-4, long run elasticities, Environmental Kuznets Curve

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INTRODUCTION

The implication of economic development on environment [also known as Environmental Kuznets Curve (EKC)] is one of the critical topics that has been studied and discussed by many researchers. Scholars are particularly interested in this area of studies due to increasing concerns about environmental degradation issues in which a worsening environment causes global warming through its greenhouse effects. Earlier studies by Grossman and Kruger (1991), Shafik (1994), and Agras and Chapman (1999) have concluded that there is an inverse U-shaped relationship between economic growth based on Gross Domestic Product (GDP) and environmental quality (e.g decrease in CO_2 emissions) in which environmental quality worsens at low levels of income and improves as income increases. However, many of these studies suffer from omitted variable bias because factors other than economic growth could also be important determinants of environmental quality (Iwata et al., 2010; Kim & Baek, 2011).

Selected empirical studies on the relationship between economic growth and other common determinants of CO_2 emissions are reviewed as follows: Lean and Smyth (2010) tested the EKC hypothesis on ASEAN5 (Malaysia, Indonesia, Thailand, Philippines and Singapore) using a panel co-integration technique based on a pooled sample. The study found that the hypothesis is only valid for ASEAN5 as a group. With the exception of Philippines, no evidence of EKC was found for Malaysia, Singapore and Thailand. In the case of Indonesia, income seems to increase monotonically with CO_2 emissions. Narayan and Narayan (2010) argued that the EKC hypothesis is not supported for developing countries such as Malaysia, Indonesia, Philippines and Thailand. However, based on the long run relationship, the error correction term (ECT) for Malaysia, Indonesia and Thailand was found to be negative and significant, thus confirming the existence of a long run relationship between growth and CO_2. In sum, while the growth-CO_2 emissions nexus is supported in general, the EKC is not supported for ASEAN, especially Malaysia, Indonesia and Thailand. Hossain (2011) examined the relationship between CO_2, energy consumption, economic growth, trade openness and urbanisation for a panel of nine newly industrialised countries that included Malaysia, Thailand and Philippines. His findings showed that income and energy consumption have a significant long run impact on CO_2 emissions in Thailand and Philippines. A more recent study was conducted by Rafiq, Salim and Nielsen (2016) to test the impact of urbanisation and trade openness on emissions and energy intensity for 22 increasingly urbanised emerging economies by using panel estimation. The empirical tests revealed that population density, income per capita and non-renewable energy consumption are the major causes of emissions and pollutions. Urbanisation though does not influence emissions rate it significantly increases energy intensity. Overall, the findings of this paper are consistent with earlier studies by Hossain (2011), Sadorsky (2013, 2014), and Shafiei and Salim (2014).

Meanwhile, studies that tested the impact of income distribution on pollution are very limited. Baek and Gweish (2013) tested the relationship between income distributions and environmental quality using an ARDL estimation technique in the United States over a 41-year period between 1967 and 2008. The authors found out that more equitable income distribution resulted in better environmental quality both in the short and long run. Additionally, the study confirmed that economic growth has a beneficial effect on environmental quality while energy consumption has a detrimental effect on the environment.

Based on recent EKC literature, several factors have been proposed as new determinants of environmental quality such as energy consumption, foreign direct investment and trade openness in addition to economic growth and income (Jalil & Mahmud, 2009; Iwata et al., 2010; Kim & Baek, 2011). However, this list of new determinants does not include income distribution (inequality) as one of the determinants of environmental quality. According to Torras and Boyce (1998), greater income equality will lead to lower levels of environmental degradation. Boyce (1994) argued that better income distribution will push society to demand for better environmental quality. Meanwhile, Heerink et al. (2001) showed that a redistribution of income has detrimental effects on the environment. Thus, these arguments based on political economy suggest that income inequality should be included as one of the determinants when testing the EKC hypothesis.

To the best of our knowledge, no study has been ever conducted thus far to examine the income inequality-environment nexus in Malaysia, Indonesia, Philippines and Thailand. This paper also offers a country-specific analysis to capture and account for the complexities of the economic environment and its determinants in the respective countries.

These ASEAN-4 countries were also selected because they have experienced steady growth rates in the past. Table 1 below shows the trend for income distribution (GINI) and level of pollution (CO_2 emissions) for the respective countries from 1971 to 2013. Overall, CO_2 emissions for all ASEAN-4 countries has shown an increasing trend. The highest rate of emissions is detected in Malaysia followed by Thailand, Indonesia and Philippines. Meanwhile, carbon dioxide release for Indonesia shows an increasing trend but occurs at a much slower rate compared with other ASEAN member countries. In the case of Philippines, CO_2 emissions occurred at a lower rate and remained almost stagnant from 1971 to 2013 with a slow decrease after this period. For income distribution, the GINI coefficients did not exhibit a consistent trend for all ASEAN-4 countries as such trend is usually influenced by a country's economic growth.

Table 1
GINI index and CO_2 emissions (metric ton per capita)

	Malaysia		Indonesia		Philippines		Thailand	
Year	GINI	CO_2	GINI	CO_2	GINI	CO_2	GINI	CO_2
1971	0.485	1.30	0.414	0.30	0.497	0.70	0.483	0.50
1975	0.491	1.60	0.476	0.40	0.500	0.80	0.483	0.60
1980	0.514	2.00	0.490	0.60	0.505	0.80	0.483	0.80
1985	0.511	2.30	0.423	0.60	0.527	0.60	0.538	0.90
1990	0.495	3.00	0.377	0.90	0.498	0.70	0.546	1.60
1995	0.502	4.20	0.393	1.20	0.517	0.90	0.580	2.70
2000	0.479	5.20	0.483	1.40	0.538	1.00	0.528	2.70
2005	0.460	6.70	0.500	1.60	0.531	0.90	0.526	3.40
2010	0.461	7.20	0.511	1.70	0.528	0.90	0.516	3.70
2013	0.461	7.70	0.520	1.80	0.528	0.60	0.516	4.00

Source: CO_2 emissions data is taken from Emission Database for Global Atmospheric Research EDGAR) database while GINI coefficient data is taken from Global Consumption and Income Project (GCIP) database.

The next section briefly explains the methodology and data used in this analysis while the remaining two sections will discuss the results and conclusions of this research paper.

METHODOLOGY

ARDL model

The empirical model used in this research is a modified version of a theoretical framework developed by Torras and Boyce (1998), Heerink et al. (2001) and Baek and Gweisah (2013) which is used to represent the long run relationship between CO_2 emissions and its major determinants in a linear logarithmic form (LN). The log-linear specifications can produce more consistent and efficient results compared with the linear model. Furthermore, as mentioned by Chang et al. (2001), this model is converted into natural logs to induce stationarity in the variance–covariance matrix. The proposed model by Baek and Gweisah (2013) is as follows: -

$$\ln(CO_2)_t = \beta_0 + \beta_1 LnY_t + \beta_2 LnG_t + \beta_3 LnE_t + \mu_{t\,t} \ldots \quad (1)$$

where CO_2 is per capita CO_2 emissions; Y is per capita real income, G is the measure of income distribution; E is energy consumption and μ is the error term. Our study extends Equation 1 by including other relevant determinants such as domestic investment (GFC) as well as trade openness (TO). Therefore, the new proposed model for this study is shown as follows:

$$\ln CO_{2t} = \omega + \alpha_1 LnGDP_t + \alpha_2 LnDI_t + \alpha_3 LnTO_t + \alpha_4 LnENC_t + \alpha_5 LNGINI_t + \mu_t \quad (2)$$

CO_2 is CO_2 emissions (measured in metric tonnes per capita), GDP is gross domestic product per capita (2005=100), domestic investment is proxied by gross fixed capital formation as % of GDP, TO is trade openness (measured in trade share of GDP), ENC is energy consumption (measured in kg oil equivalent per capita), and GINI is the Gini coefficient representing income distribution.

With respect to the signs of coefficients in Equation (2), α_1 is expected to be positive while α_2, α_3, α_4 and α_5 are expected to be either positive or negative. It should be mentioned that recent research in econometrics has indicated that the Autoregressive distributed lag (ARDL) approach used in co-integration developed by Pesaran, Shin and Smith (2001) is superior compared with other conventional co-integration approaches such as Engle and Granger (1987) and Johansen and Juselius (1990). Thus, the hypothesised loglinear functional form between variables is used in order to perform an ARDL bound F test to examine the existence of a long run relationship. In this regard, an ARDL equation known as the Unrestricted Error Correction Model (UECM) is constructed as shown in Equation 3 below:

$$\Delta LnCO_{2t} = \beta_0 + \sum_{i=1}^{a} \beta_i \Delta LnCO_{2t-i} + \sum_{i=0}^{b} \gamma_i \Delta LnGDP_{t-i} + \sum_{i=0}^{c} \delta_i \Delta LnDI_{t-i} + \sum_{i=0}^{d} \xi_i \Delta LnTO_{t-i} + \sum_{i=0}^{e} \psi_i \Delta LnENC_{t-i} + \sum_{i=0}^{f} \omega_i \Delta LnGINI_{t-i} + \gamma_0 LnCO_{2t-1} + \gamma_1 LnGDP_{t-1} + \gamma_2 LnDI_{t-1} + \gamma_3 LnTO_{t-1} + \gamma_4 LnENC_{t-1} + \gamma_5 LnGINI_{t-1} + \mu_t \quad (3)$$

where Δ is the first-difference operator and u_t is a white-noise disturbance term. Residuals for the UECM should be serially uncorrelated and the model should be stable. This final model can also be viewed as an ARDL of order, (a, b, c, d, e, f). The model indicates that in order for environmental quality (CO_2) to be influenced and explained by its past values, it has to involve other disturbances or shocks. The null hypotheses of no co-integration against the alternative hypothesis of existence of a long run co-integration are defined as:

$$H_0: \gamma_0 = \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = 0$$
$$H_1: \gamma_0 \neq \gamma_1 \neq \gamma_2 \neq \gamma_3 \neq \gamma_4 \neq \gamma_5 \neq 0 \quad (4)$$

and is tested using the usual F-test. However, the asymptotic distribution of this F-statistic is non-standard irrespective of whether the variables are I (0) or I (1). In Equation 3 above, the long run (cointegration) relationship is represented by the coefficients of γ, whereas the short run dynamics is determined by the coefficients of the summation signs, $\sum$. Hence, Equation 3 is called an error-correction representation of the ARDL model.

It should be noted that the annual data used in this study covers the period from 1971 until 2013. The data span has been chosen based on availability of data for all series. Most of the data were extracted from the World Development Indicator (WDI) 2016 released by the World Bank.

RESULTS AND DISCUSSION

We performed three types of unit root tests consisting of Augmented Dickey Fuller (ADF) and Philipp Perron (PP) in order to determine the order of stationarity for each variable. These preliminary tests were run in order to determine the most suitable regression technique based on the evidence of stationarity on each data. If the data is only significant at I (1), then we can proceed with the analysis using either the Johansen and Juselius co-integration or the ARDL test. However, if there is mix evidence of stationarity at both I (0) and I (1), then we can only proceed with the analysis by using the ARDL estimation as long as the data is not stationary at I (2). Table 2 shows the results of unit root tests for all variables. Overall, mixed stationarities of variables were detected such as TO in Indonesia while DI and ENC were detected in Philippines based on ADF and PP unit root. All variables were found to be stationary (1% to 5% significance levels) only at the first difference when using ADF and PP unit root test for both Malaysia and Thailand. The condition described above fulfils the requirement to proceed with the analysis using ARDL estimation.

Table 2
Results of ADF and PP unit root tests

Country		Variable Intercept	ADF test statistic		PP test statistic	
			Trend and intercept	Intercept	Trend and intercept	
Malaysia	Level	$LNCO_2$	-0.943 (0)	-1.633 (0)	-0.958 (3)	-1.794 (1)
		LNGDP	1.248 (0)	-1.653 (0)	1.250 (1)	-1.705 (1)
		LNDI	-2.443 (1)	-2.569 (1)	-2.068 (1)	-2.217 (1)
		LNTO	-2.287 (1)	-0.317 (1)	-1.770 (1)	0.306 (4)
		LNENC	-1.005 (0)	-2.043 (0)	-1.559 (11)	-2.081 (1)
		LNGINI	-0.608 (1)	-2.605 (1)	-0.517 (4)	-2.367 (3)
	First difference	$LNCO_2$	-5.957 (0) ***	-6.019 (0) ***	-5.948 (2) ***	-6.012 (2) ***
		LNGDP	-5.929 (0) ***	-6.186 (0) ***	-5.931 (1) ***	-6.186 (1) ***
		LNDI	-4.670 (0) ***	-4.607 (0) ***	-4.610 (3) ***	-4.543 (3) ***
		LNTO	-5.053 (0) ***	-5.858 (0) ***	-5.053 (0) ***	-5.863 (5) ***
		LNENC	-6.705 (0) ***	-6.784 (0) ***	-6.912 (6) ***	-9.821 (14) ***
		LNGINI	-3.772 (0) ***	-3.953 (0) **	-3.737 (2) ***	-3.955 (2) **
Indonesia	Level	$LNCO_2$	-1.984 (0)	-1.613 (0)	-2.063 (1)	-1.353 (2)
		LNGDP	-1.0300 (1)	-2.252 (1)	-1.192 (1)	-2.001 (2)
		LNDI	-2.234 (7)	-2.689 (7)	-1.873 (1)	-2.094 (2)
		LNTO	-3.481 (0) **	-3.421 (0) *	-3.433 (3) **	-3.382*
		LNENC	-1.124 (0)	-1.035 (0)	-1.164 (3)	-1.035 (0)
		LNGINI	-1.491 (4)	-1.689 (4)	-1.775 (3)	-1.871 (3)
	First difference	$LNCO_2$	-2.235 (4)	-2.700 (4)	-6.553 (3) ***	-7.276 (2) ***
		LNGDP	-4.717 (0) ***	-4.729 (0) ***	-4.717 (0) ***	-4.729 (0) ***
		LNDI	-4.547 (0) ***	-4.498 (0) ***	-4.485 (5) ***	-4.440 (5) ***
		LNTO	-3.481 (0) **	-3.421 (0) *	-6.013 (1) ***	-6.168 (1) ***
		LNENC	-6.364 (0) ***	-6.459 (0) ***	-6.364 (2) ***	-6.479 (3) ***
		LNGINI	-2.222 (3)	-6.060 (2) ***	-3.689 (37) ***	-3.834 (37) **

Table 1 (*continue*)

Philippines		$LNCO_2$	-1.654 (0)	-2.268 (2)	-1.691 (2)	-2.030 (2)
		LNGDP	0.555 (2)	-0.686 (2)	0.236 (2)	-0.802 (3)
	Level	LNDI	-3.409 (1) **	-4.191 (8) *	-2.573 (1)	-2.729 (2)
		LNTO	-1.476 (0)	0.020 (0)	-1.509 (3)	-0.086 (2)
		LNENC	-2.703 (3) *	-2.687 (3)	-2.613 (3) *	-2.485 (3)
		LNGINI	-1.665 (7)	-2.147 (7)	-2.023 (1)	-2.408 (0)
		$LNCO_2$	-3.857 (1) ***	-3.812 (1) **	-7.357 (2) ***	-7.269 (2) ***
		LNGDP	-3.373 (0) **	-3.305 (3) *	-3.373 (0) **	-3.476 (2) *
	First difference	LNDI	-4.903 (1) ***	-4.943 (1) ***	-4.603 (4) ***	-4.572 (4) ***
		LNTO	-5.085 (0) ***	-5.548 (0) ***	-5.085 (2) ***	-5.567 (1) ***
		LNENC	-8.902 (0) ***	-9.024 (0) ***	-8.538 (3) ***	-8.666 (3) ***
		LNGINI	-4.340 (6) ***	-4.417 (6) ***	-5.976 (3) ***	-5.933 (4) ***
Thailand		$LNCO_2$	-0.884 (2)	-1.658 (2)	-1.167 (2)	-1.021 (2)
		LNGDP	-1.250 (1)	-1.791 (1)	-0.969 (3)	-1.448 (3)
	Level	LNDI	-2.518 (1)	-2.481 (1)	1.875 (1)	-1.583 (0)
		LNTO	-1.207 (0)	-2.271 (0)	-1.216 (1)	-2.305 (2)
		LNENC	-0.017 (1)	-2.692 (3)	0.051 (4)	-2.024 (4)
		LNGINI	-1.453 (0)	-0.964 (0)	-1.526 (2)	-1.029 (1)
		$LNCO_2$	-2.836 (1) *	-3.034 (2)	-6.441 (2) ***	-6.584 (2) ***
		LNGDP	-3.945 (0) ***	-4.038 (0) **	-3.945 (0) ***	-4.067 (1) **
	First difference	LNDI	-4.465 (1) ***	-4.500 (1) ***	-3.927 (6) ***	-3.899 (6) **
		LNTO	-6.911 (0) ***	-6.899 (0) ***	-6.915 (1) ***	-6.902 (1) ***
		LNENC	-4.823 (0) ***	-4.783 (0) ***	-4.921 (3) ***	-4.885 (3) ***
		LNGINI	-5.642 (0) ***	-5.790 (0) ***	-5.642 (0) ***	-5.794 (2) ***

Note: 1. ***, ** and * denotes rejection of null hypotheses (nonstationarity for the ADF and PP) at 1%, 5% and 10% level. 2. The optimal lag length is selected automatically using the Akaike information criteria for ADF test and the bandwidth is selected using the Newey–West method for the PP test. 3.

Subsequently, to confirm the existence of a long run relationship between the variables for all four countries, the analysis proceeded with the F-tests and the results are displayed in Table 3. The maximum lag of 4 was imposed in each model using the Akaike Information Criterion (AIC). The F statistics for Malaysia, Indonesia, Philippines and Thailand (6.257, 5.576, 3.640 and 4.567, respectively) are higher than the upper I (1) critical value (significant either at 1% level, 5% level or 10% level), thus confirming the existence of long run relationships.

Table 3
Results of ARDL co-integration tests

Model	Maximum lag	Lag order (a,b,c,d,e,f)	F Statistic
Malaysia	4	(1,0,0,0,1,0)	6.257***
Indonesia	4	(2,4,4,4,4,4)	5.576***
Philippines	4	(2,1,1,0,3,0)	3.640*
Thailand	4	(2,0,2,1,0,0)	4.567**
Critical Values for *F*-statistics#		Lower bound, I (0)	Upper bound, I (1)
	1%	3.41	4.68
k = 5	5%	2.62	3.79
	10%	2.26	3.35

Note: # The critical values are obtained from Narayan (2004), k is number of variables, critical values for the bounds test: case III: unrestricted intercept and no trend. *, **, and *** represent 10%, 5% and 1% levels of significance respectively.

Diagnostic tests were performed for all models to make sure that the long run estimation produces reliable results. Table 4 shows that the models have the desired econometric properties, namely that they have no autocorrelation problems, have a correct functional form, have residuals that are serially uncorrelated, and are free from homoscedastic problems given that the probability value of the t-tests are all above the 10% significance value (fail to reject H_0).

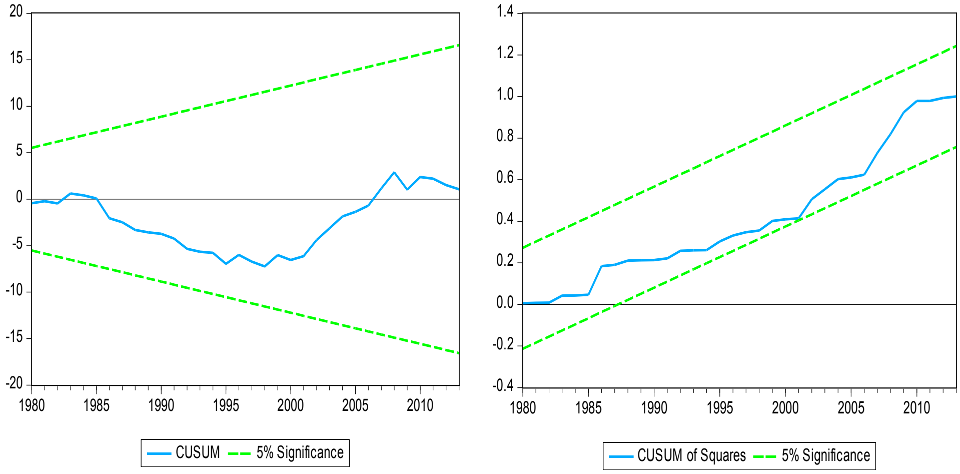
Table 4
Results of Diagnostic Checking

Country	Serial correlation	Functional form	Normality	Heteroscedasticity
	H_0=There is no autocorrelation	H_0=The model is correctly specified	H_0=Residual are normally distributed	H_0=There is no heteroscedasticity
Malaysia	0.825 [0.447]	0.0001 [0.991]	1.041 [0.594]	0.681 [0.686]
Indonesia	3.043 [0.157]	0.270 [0.625]	0.947 [0.622]	2.102 [0.179]
Philippines	0.742 [0.486]	2.636 [0.116]	3.117 [0.210]	0.434 [0.934]
Thailand	1.096 [0.347]	1.332 [0.257]	0.840 [0.656]	1.135 [0.370]

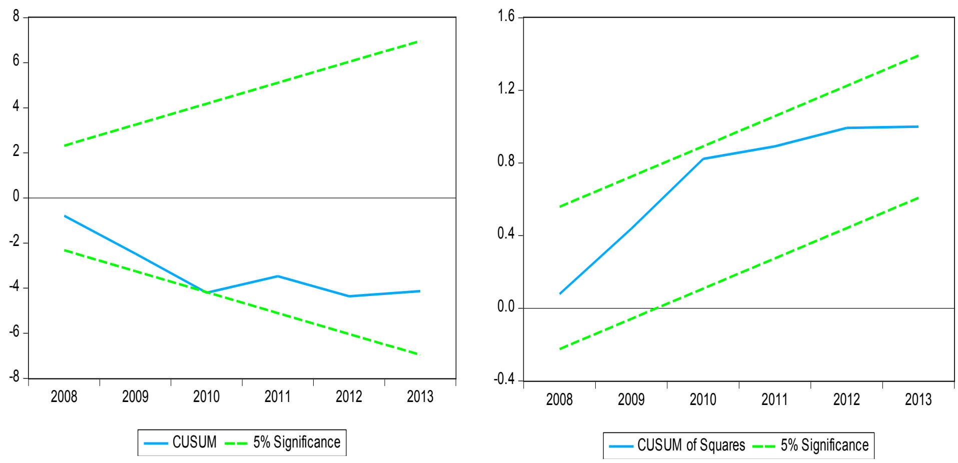
Note: 1. The numbers in brackets [ ] are p-values. 2. The tests run for diagnostic check are Jarque-Bera (normality), Ramsey RESET (functional form), Breusch Godfrey LM test (autocorrelation) and Breusch Pagan Godfrey (heteroscedasticity).

Additionally, the cumulative sum of recursive residuals (CUSUM) and CUSUM of squares (CUSUMSQ) tests were performed to test for structural stability of each model (Figure 1). The results show that the estimated coefficients are generally stable over the tested period. Overall, the ARDL models presented in this study are well defined and provide sound findings.

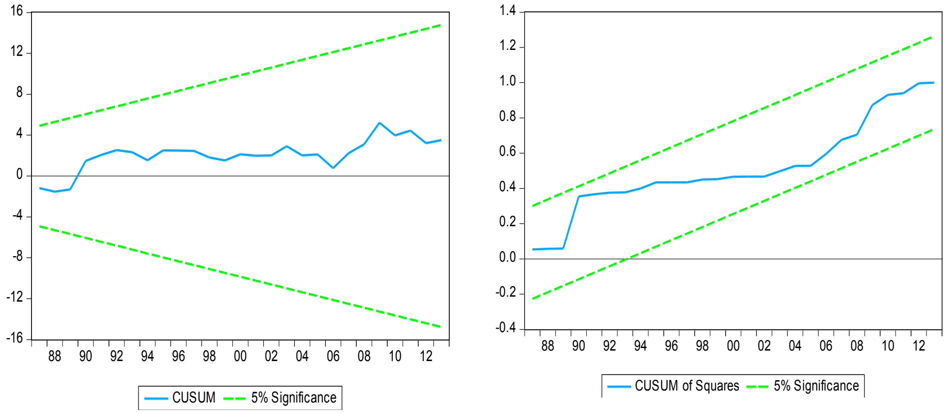
Malaysia



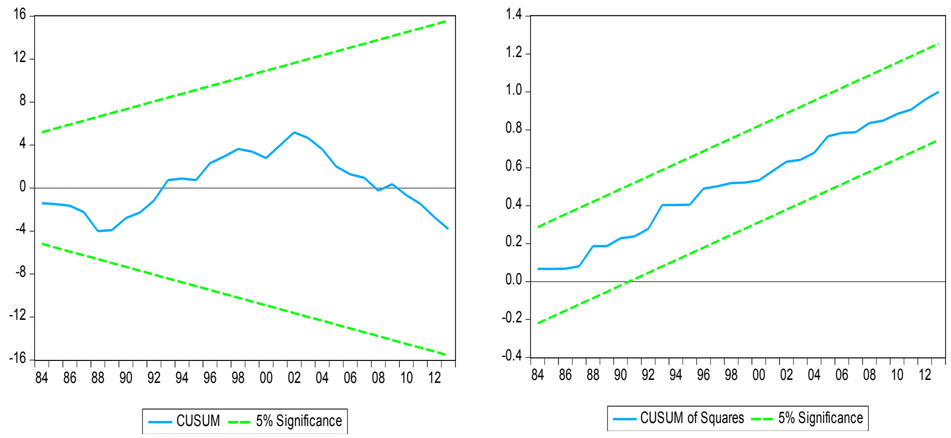
Indonesia



Philippines



Thailand



Note: 1. The straight lines represent critical bounds at 5% significant level. 2. CUSUM graph is at the left side while CUSUM SQ graph is at the right side.

Figure 1. CUSUM and CUSUM SQ

Table 5 below presents the estimates of the long run elasticities from the ARDL analysis. It was found that GDP acts positively and significantly at 1% level to CO_2 emissions level in Malaysia and Indonesia respectively. This means that real GDP affects the level of CO_2 emissions in both countries and this result is in line with previous studies by Jalil and Mahmud (2009), Bhattacharyya and Ghoshal (2010) as well as Hakimi and Hamdi (2016). As for Philippines and Thailand, the GDP displayed a negative relationship with CO_2 emissions but was not significant at any level.

The impact of DI (proxies by gross domestic investment as % of GDP) on CO_2 emissions is found to be positive for Philippines but negative for Indonesia. No significant relationship is detected for ARDL estimation between DI and CO_2 emissions for Malaysia and Thailand. The significant and positive sign of DI in Philippines indicates that domestic investment or capital contributes to CO_2 emissions in the long run. This is not surprising since domestic production technologies in Philippines have not fully adopted advanced technologies that are able to reduce CO_2 emissions, therefore, contributing heavily to pollution. This finding is similar to Hakimi and Hamdi's (2016) who noted that domestic investment directly worsens the environmental quality of Tunisia and Morocco. As for Indonesia, surprisingly, domestic ventures use environmentally-friendly technology and thus, reduce environmental degradation.

The TO was found to have a positive correlation with CO_2 emissions for Malaysia, Indonesia and Philippines at 1% and 5% significance level. Meanwhile, TO cannot explain CO_2 emissions in the case of Thailand. Technically, 1% increase in TO will increase CO_2 emissions by 0.20% for Malaysia, 1.35% for Indonesia and 0.80% for Philippines. The positive relationship between TO and CO_2 emissions reveals that free trade damages environmental quality in these countries. Additionally, based on recent findings by Copeland and Taylor (2013), a higher degree of openness in trade will shift the polluting industry from developed countries to developing countries such as Malaysia, Indonesia and Philippines as they could produce more ‘dirty’ goods in countries that have weaker environmental regulations.

Next, ENC (energy consumption) is statistically significant for all ASEAN-4 countries except for Philippines. The results imply that as ENC increases by 1%, the level of CO_2 emissions increases by 0.31% (Malaysia) and 1.18% (Thailand). Recent economic developments in these countries may have led to higher energy consumption, increasing CO_2 emissions. Our findings are supported by Linh and Lin (2012) and Tang and Tan (2015), who also noted that energy consumption contributes significantly to CO_2 emissions. Meanwhile, 1% increase in ENC will improve the environmental quality in Indonesia by about 3.15%. The outcome basically shows that Indonesia has successfully managed to convert its energy consumption by using cleaner energy which helps to reduce the release of CO_2 emissions.

The main contribution of this paper is assessing the impact income inequality (GINI) on CO_2 emissions. The only country which has a negative relationship between GINI and CO_2 emissions is Malaysia. This means that a higher GINI coefficient (lower income equality) is associated with higher CO_2 emissions or from the result, a 1% increase in GINI will increase environmental degradation by 2.35%. According to Boyce (1994), increased income inequality makes the distribution of political power more favourable to the rich group, enabling it to influence decisions on economic returns versus environmental damage. This scenario could occur in Malaysia. As for Indonesia and Thailand, the positive signs indicate that low GINI (greater income equality) decreases CO_2 emissions. In other words, a 1% decrease in GINI will decrease pollution by 0.69% for Indonesia and 2.76% for Thailand. This finding supports the political economy argument that more equal distribution of power and income over the past four decades for these countries has increased the demand by citizens of Indonesian and Thailand for a cleaner environment which in turn has induced positive policy responses leading to a more stringent environmental standards and stricter enforcement of environmental laws, thereby enhancing environmental quality. The above outcomes for Indonesia and Thailand are similar to those in the United States (Baek & Gweisah, 2013). As for the Philippines, there is no significant relationship between GINI and CO_2 emission levels.

Table 5
Estimation of Long Run Elasticities

Variable	Malaysia $LNCO_2$ (1,0,0,0,1,0)	Indonesia $LNCO_2$ (2,4,4,4,4,4)	Philippines $LNCO_2$ (2,1,1,0,3,0)	Thailand $LNCO_2$ (2,0,2,1,0,0)
LNGDP	0.6157***	3.757***	-0.261	-0.154
LNDI	0.098	-1.305**	0.719*	0.133
LNTO	0.201***	1.357***	0.802**	0.081
LNENC	0.313**	-3.152**	-2.970	1.181***
LNGINI	-2.353***	0.696***	0.835	2.764***
Constant	-9.055***	-6.502***	14.714	-5.199***

Note: 1. *, ** and *** indicate significant at 10%,5% and 1% significance level respectively.

Table 6 below shows the outcome for the estimation of short run elasticities. The GDP is positive and significant at the 1% level for Malaysia, Indonesia and Thailand. Besides, DI has positive influence on CO_2 emissions for both Malaysia and Thailand. Moreover, TO and ENC also have a significant positive effect on CO_2 emissions for all ASEAN-4 countries. However, TO has a negative impact on CO_2 emissions at a higher lag order. This mean that in the short run, the ENC for all ASEAN-4 countries contributes towards higher environmental degradations. The short term impact between GINI and CO_2 emissions for all ASEAN-4 countries are similar with the long term impact.

The long run relationship based on the ECM model is also supported via the negative and significant values of error correction term (ECT) that was obtained for each model. It should be noted that ECT reflects the speed of adjustment for each model and the negative value means that the variables in the model will converge in the long run. In this respect, the highest speed of adjustment was detected for Indonesia (-1.14), followed by Malaysia (-0.55), Thailand (-0.45) and Philippines (-0.33). Given that the ECT value for Indonesia is more than 1, it shows that the adjustment speed is very fast from a short run to a long run equilibrium. Specifically, if the actual equilibrium value is too high, the error correction term will reduce it, while if it is too low, the error correction term will raise it. In this regard, the ECT coefficients for Malaysia (-0.55), Thailand (-0.45) and Philippines (-0.33) indicate that when CO_2 emissions deviate from its long-run equilibrium level, it adjusts at about 55%, 45% and 33% respectively within the first year. The variables explain well over at least 89% of the variations in all three models. This is adjusted by the value of the coefficient of determination, Adjusted R-squared.

Table 6
Estimation of Short Run Error Correction Model (ECM)

Malaysia		Indonesia	
Variables	Coefficient	Variables	Coefficient
Δ(LNGDP)	0.341***	Δ ($LNCO_2$(-1))	0.958***
Δ(LNDI)	0.0543*	Δ (LNGDP)	1.208*
Δ(LNTO)	0.111***	Δ (LNGDP (-1))	-1.956**
Δ(LNENC)	0.425***	Δ (LNGDP (-2))	-1.687*
Δ(LNGINI)	-1.304***	Δ (LNGDP (-3))	2.313**
ECT	-0.554***	Δ (LNDI)	-0.441
		Δ (LNDI (-1))	0.2759
		Δ (LNDI (-2))	-0.398
		Δ (LNDI (-3))	0.330
		Δ (LNTO)	0.038
		Δ (LNTO (-1))	-0.310**
		Δ (LNTO (-2))	-0.552***
		Δ (LNTO (-3))	-0.159
		Δ (LNENC)	0.420
		Δ (LNENC (-1))	0.174***
		Δ (LNENC (-2))	2.211**
		Δ (LNENC (-3))	1.014
		Δ (LNGINI)	0.646
		Δ (LNGINI (-1))	-1.420**
		Δ (LNGINI (-2))	-0.801
		Δ (LNGINI (-3))	1.365***
		ECT	-1.140***
Ad.Rsquare	0.99	Ad. Rsquare	0.99
Philippines		Thailand	
Variables	Coefficient	Variables	Coefficient
Δ ($LNCO_2$(-1))	-0.247	Δ ($LNCO_2$(-1))	-0.437***
Δ (LNGDP)	0.938*	Δ (LNGDP)	-0.070
Δ (LNDI)	-0.147	Δ (LNDI)	0.244**
Δ (LNTO)	0.272***	Δ (LNDI (-1))	0.226*
Δ (LNENY)	0.902**	Δ (LNTO)	0.312**
Δ (LNENY(-1))	0.104	Δ (LNENY)	0.537***
Δ (LNENY (-2))	1.058***	Δ (LNGINI)	1.256***
Δ (LNGINI)	0.280	ECT	-0.454***
ECT	-0.339***		
Ad. Rsquare	0.89	Ad. Rsquare	0.99

Note: 1. Δ refer to first difference. 2. Dependent variable is Δ$LNCO_2$). 3. (*), (**), (***) indicate significance at 10%,5% and 1% levels. 4. Ad. Rsquare is refer to adjusted R square.

CONCLUSION

The primary objective of this study was to investigate the short and long term effects of income inequality, domestic investment, trade openness, per capita real income and energy consumption on CO_2 emissions in Malaysia, Indonesia, Philippines and Thailand. The results of the ARDL tests show that income inequality and CO_2 emissions for Indonesia and Thailand have positive relationships, implying that greater equality in the distribution of income of these countries has a favourable outcome on its environmental quality. Malaysia, on the other hand, shows a negative correlation between income inequality and CO_2 emissions, suggesting that increased equality in income distribution worsens the pollution levels. This study also concludes that more equitable income distribution that occurs in countries such as Indonesia and Thailand will encourage their citizens to demand for a cleaner environment in order to achieve a better quality of life. Improvement in income will increase awareness of these people of the need to take better care of their environment, besides imploring their respective governments to impose stricter laws or policies in order to reduce environmental degradation that can occur as a result of development in their respective countries.

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