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Article

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The Impact of Corruption on Environmental Quality in the Developing Countries of ASEAN-3: The Application of the Bound Test

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ABSTRACT

This paper has examined the short-run and long-run relationships between economic growth, energy consumption, foreign direct investment, trade openness, financial development, corruption, urban population and carbon dioxide (CO₂) emissions in three developing countries of ASEAN, i.e., Malaysia, Indonesia and the Philippines (ASEAN-3), with data from 1970 to 2017. Special emphasis has been given to the level of corruption in these three countries as several recent media releases have reported that many firms have been conducting unlawful activities by importing large amounts of waste from developed countries and these wastes, including plastic waste, have been burnt in open spaces and have caused higher releases of carbon emissions. Long-run elasticity results have proven that the higher level of corruption in these three ASEAN countries has caused more environmental pollution. Meanwhile, other tested variables have shown mixed findings across the three tested countries. Improvement of institutional quality is urgently needed for ASEAN-3 countries by adopting more transparent laws and the imposition of heavier penalties on corrupt officials and even on the entrepreneurs who have engaged in unlawful business activities that have caused higher environmental pollution.

Keywords: Environmental Quality, Corruption, Bound Estimation, ASEAN-3

JEL Classifications: F64, O57, P28

1. INTRODUCTION

The continuing issues of global warming, air pollution and other environmental problems have generated consciousness on the importance of environmental quality (Dasgupta et al., 2004). In addition, the upsurge of environmental adverse impacts, such as unpredictable climate change, earthquakes, flash floods and tsunamis, particularly in the Southeast Asian region, has caused concern among environmentalists and economists and has driven them to seriously focus on the issues of environmental deterioration. Recent theoretical and case studies have proposed that one of the main factors that contribute to environmental degradation is the lack of control of corruption levels that initiate

a reduction in the stringency of environmental regulations (Sekrafi and Sghaier, 2018; Umer et al., 2014; Lopez and Mitra, 2000).

According to the World Bank (2005), corruption is the abuse of entrusted power by public or corporate institutions for private gain. Dzhumashev (2014) has discovered that the incidence of corruption declines with economic development. This is because, with economic development, the wage rate rises and makes private rent-seeking costs higher, thereby discouraging corruption. On the other hand, the 2018 Corruption Perceptions Index (CPI) has revealed that most countries in the world have significantly failed to control corruption levels and this has contributed to a crisis of democracy around the world. The statistics of the CPI

in 2018, with a minimum score of zero (highly corrupted) to 100 (very clean) have shown that 80% of ASEAN countries, except for two-high income countries, i.e., Singapore and Brunei (with scores of 85 and 63, respectively), achieved scores of below 50 points, with an average score of 42 points. This shows that the level of transparency, democracy and integrity of ASEAN countries is still low, chiefly in public institutions (CPI, 2018).

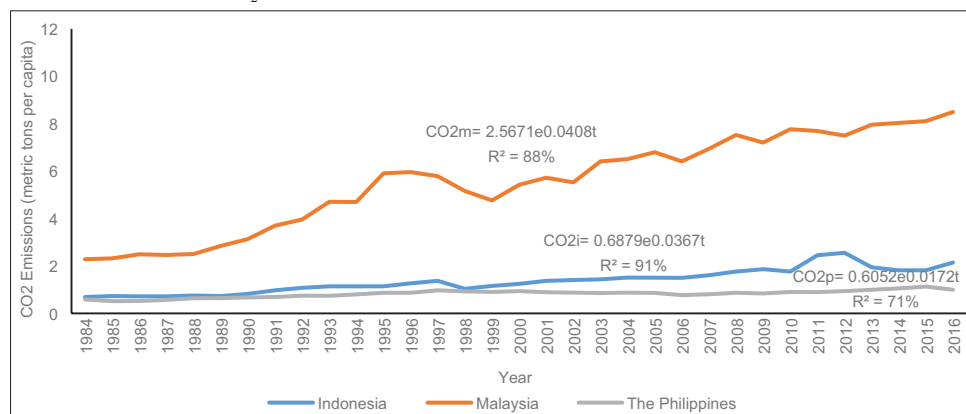
Meanwhile, in terms of environmental quality, most ASEAN countries have been actively involved in the urbanisation and industrialisation process. Fossil fuel combustion, especially through industrialisation; development of commercial and residential buildings during urbanisation; and deforestation in the agriculture sector are among the main causes that accelerate the increase of greenhouse gases (GHGs), especially CO₂. CO₂ has the greatest impact on global warming due to its relatively high emission into the atmosphere compared to other GHGs (Lee et al., 2012). According to IEA (2018), the main contributors of CO₂ emissions in ASEAN countries, especially in Malaysia, Indonesia and the Philippines, are electricity, heat production and the transportation sector. In electricity generation from power plants specifically, CO₂ is produced when fuel is combusted in air. Currently, in ASEAN countries, low carbon technologies and renewable energy are still at the preliminary stage and have yet to replace traditional power plants (Lee et al., 2013). Thus, fossil fuel remains the most dominant energy source due to its wide availability and economic viability (Mangalapally et al., 2009). The transportation sector is another significant contributor to CO₂ emissions, particularly in Indonesia and the Philippines (IEA, 2015). CO₂ from vehicles is produced from engine combustion and catalytic converters, which convert harmful carbon monoxide (CO) from incomplete combustion into CO₂. Meanwhile, with the development of the agriculture sector in ASEAN countries, deforestation and wildfires, especially in Indonesia, have caused heavy haze in western Indonesia, Malaysia and Singapore. Haze from forest fires is an annually occurring socio-ecological crisis in Indonesia that releases amounts of greenhouse gases (GHGs) that are monumental in scale. The Center for International Forestry Research has found that in 2013, one week of blazes in an Indonesian forest with just 1.6% of the country's total land area released emissions equivalent to 5% to 10% of Indonesia's annual GHG emissions (Yudha, 2016). Based on Figure 1, the

CO₂ emissions for Malaysia, Indonesia and the Philippines, respectively, grew by 4.1%, 3.7% and 1.7% per year from 1980 to 2016. According to IEA (2015), Malaysia is the third-highest CO₂ emissions producer in ASEAN (7.27 tons per capita) after Brunei and Singapore, mainly through electricity generation, transport services, manufacturing and others (residential, commercial and agriculture).

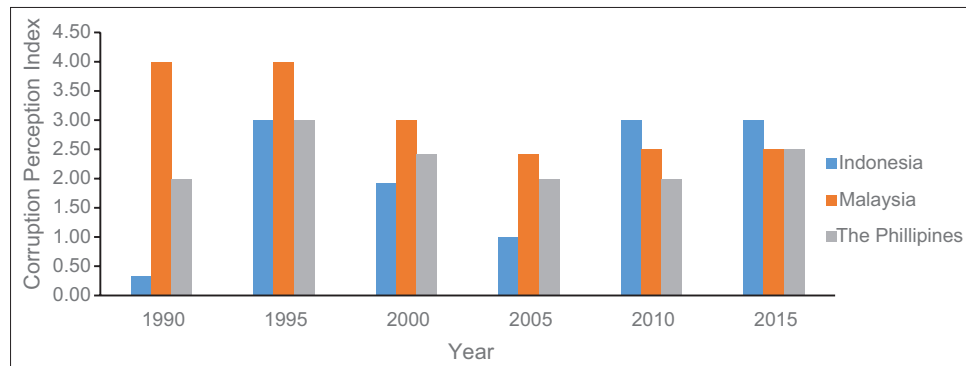
Due to the escalating problems with environmental quality in these ASEAN-3 countries, there has been a need to study the development and delivery of effective environmental regulation by the environmental authorities. These authorities, whether from the public or private sector, should enforce good governance that is capable of delivering the reliable and quality services that are required to drive sustainable development (UNDP, 2018). Hence, these authorities need to be free from corruption. The existence of independent institutions, which can hold the government accountable, and which can impact their decision-making process, is also important (Gani, 2012). Examining the corruption indexes for ASEAN-3 countries in Figure 2, it can be seen that the corruption index in Malaysia has shown a downward trend from 4 points in 1990-2.5 points in 2005. It was then stable at 2.5 points until 2015. Indonesia showed a very low corruption rate in 1990 of <0.5 points, but the rate increased to 3 points in 1995. Nonetheless, the trend declined again in 2000 and 2005 before increasing again in 2010 and 2015-3 points. The Philippines showed a stable downward and upward trend from 2 points to 3 points in 1990 and 2010, and achieved 2.5 points in 2015. These findings have revealed that the corruption indexes have been considerably high and improvement in the quality of institutions and in corruption levels is needed to achieve sustainable development (Owen, 2013).

Consequently, due to the aforementioned concerns on environmental quality, especially in CO₂ emissions, this study has investigated the nexus between corruption and CO₂ emissions, specifically in the context of the ASEAN-3 countries. In recent years, several studies have been carried out in this regard in other regions (Leitão, 2010; Hassaballa, 2015; Sekrafi and Sghaier, 2016; Wang et al., 2018; Sekrafi and Sghaier, 2018; Nguyen et al., 2018), but no studies have yet been completed in ASEAN countries. Thus, it was essential to conduct research on the long-run and short-run relationships between corruption and environmental quality in

Figure 1: Trend of CO₂ emissions in Indonesia, Malaysia and the Philippines from 1984 to 2016



Source: World Development Indicators (2019)

Figure 2: Corruption Perceptions Index in Indonesia, Malaysia and the Philippines from 1990 to 2015

Source: 2018 Corruption Perceptions Index (CPI, 2018)

ASEAN-3 countries. Pertaining to the nexus between corruption and environment quality, Gani (2012) has discovered strong evidence that control of corruption as part of governance indicators is significant and negatively correlated with CO₂ emissions per capita, thus providing support to anti-corruption measures in terms of reducing CO₂ emissions.

The rest of this paper has been structured as follows. Section 2 discusses past empirical analyses of governance and environmental quality. Section 3 describes the data sources and the methodologies for model development. The empirical findings are discussed in Section 4. Finally, Section 5 presents the conclusions and policy implications drawn from the results of the study.

2. LITERATURE REVIEW

2.1. Corruption and Environmental Quality

Corruption influences the dysfunctional environmental governance systems that contribute to the extinction of species; the over-exploitation of natural resources; the pollution and degradation of ecosystems and wildlife habitats; the spread of diseases and invasive species; and the deprivation of local stakeholders related to wildlife and plants (Sekrafi and Sghaier, 2018). The discussion of corruption and environmental quality can be approached from two schools of thought. The first school of thought investigates the implications of corruption on the Environmental Kuznets Curve (EKC) and is also known as the direct effect of corruption. Grossman and Krueger (1991) initially introduced the EKC and revealed that in the early stages of economic growth, environmental quality tends to deteriorate. It then improves after the economy has exceeded a certain income threshold level. Similar studies have utilised the EKC in various countries and their findings have shown consistent results of inverted U-shaped EKCs whereby the environmental quality has improved with enhancement in technology and changes in economic structures from agriculture-based industries to service-based industries (Alshehry and Belloumi, 2017; Bekhet and Othman, 2017; Nasreen et al., 2017; Shahbaz et al., 2017; Riti et al., 2017; Dogan and Turkekul, 2016; Al-Mulali et al., 2015). The latest studies on the EKC have further extended the previous research by looking at the role of the corruption level in overcoming environmental degradation, principally in developing countries (Lopez and Mitra, 2000; Rehman et al., 2012; Leitão, 2010; Sahli and Rejeb, 2015).

More than that, the study of environmental change and governance indicators cannot be separated from policies and economic reformation (Gani, 2012) in order to conserve a sustainable environment. Leitão (2010) has described the various degrees of corruption in a wide range of countries at different stages of development. His findings have suggested that the higher the level of a country's corruption, the higher the per capita income at the turning point of the EKC, suggesting different income-pollution paths across countries due to corruption. This result was consistent with the conclusions of Rehman et al. (2012) where they indicated that corruption affects the environment by delaying the turning point in the EKC. With the presence of corruption, the per capita GDP at the turning point for South Asian countries was USD 998, which was USD 128 higher than the value that it would have been in the absence of corruption. Zhang et al. (2018) have discovered the existence of an inverted U-shaped EKC between corruption and CO₂ emissions in Asia-Pacific Economic Cooperation (APEC) countries, showing that per capita GDP at the turning point of the EKC may increase when CO₂ emissions increase.

The second school of thought focuses on the nexus between corruption and CO₂ emissions and is called the indirect effect of corruption on the environment. Welsch (2004) has discovered that a number of indicators of the environment monotonically increase with corruption and the relationship is found to be strong at low-income levels. Hassaballa (2015) has pointed out that corruption, per capita income, trade openness and manufacturing value added were significant determinants of CO₂ emissions in the Middle East and North African region over the period 1996-2013. Ozturk and Al-Mulali (2015), meanwhile, have investigated the effect of control of corruption on CO₂ emissions in Cambodia and have concluded that control of corruption can reduce CO₂ emissions. Their study has suggested that both governance and control of corruption can assist in reinforcing environmental regulation and can induce industry to shadow this regulation. Good governance also stimulates political freedom and raises public awareness towards improving the environment (Gani, 2012). Leitão (2010) has highlighted flaws in governance structures and has stated that good governance, including a broad commitment to the rule of law, is crucial for environmental sustainability and is one way to put a stop to the devastating impact that corruption has on the environment. Recently, Zhang et al. (2018) examined the direct and indirect effects of corruption on CO₂ emissions and concluded that

corruption increases CO₂ emissions and may worsen the overall environmental quality of APEC countries. Meanwhile, Wang et al. (2018) have concluded that corruption as a moderating factor is crucial in the relationship between economic growth and CO₂ emissions and that control of corruption reduces CO₂ emissions. In addition, this study has revealed the significant moderating effect of corruption on the nexus between urbanisation and CO₂ emissions in the case of BRICS countries (i.e., Brazil, Russia, India, China and South Africa), which signifies poor environmental performance in these countries.

3. METHODOLOGY

The model formulation for this study is briefly explained in this section. The determinants of environmental quality, represented by the level of carbon emissions for Indonesia, Malaysia and the Philippines, were carefully chosen based on selected macroeconomic indicators of these nations. The general functional form of the model was derived as follows:

$$CO_{2t} = f(GDP_t, ENY_t, FDI_t, TO_t, FD_t, COR_t, UPOP_t) \quad (1.0)$$

Where:

- CO_{2t} represents carbon dioxide,
- GDP_t represents economic growth,
- ENY_t represents energy consumption,
- FDI_t represents foreign direct investment inflows,
- TO_t represents trade openness,
- FD_t represents financial development,
- COR_t represents the corruption index, and
- UPOP_t represents urban population.

All of the variables were transformed into log-linear forms (LN). This transformation was to convert the results into short-run and long-run elasticities and to reduce the sharpness of the time series data so that there was a consistent and reliable estimation. The log version of the model derived from Equation 1.0 was as follows:

$$LNCO_{2t} = \alpha_0 + \beta_1 LNGDP_t + \beta_2 LNENY_t + \beta_3 LNFDI_t + \beta_4 LNTOT_t + \beta_5 LNFD_t + \beta_6 LNCOR_t + \beta_7 LNUPOP_t + \mu_t \quad (2.0)$$

GDP is expected to have a positive sign with CO₂ and this estimation is considered normal, especially for developing countries like the ASEAN-3 countries. ENY could possibly have a positive or negative sign depending on the availability of renewable energy in the countries. FDI is expected to have a negative sign as most of the past findings have confirmed the validity of the Halo Effect hypothesis where most developed countries transfer greener and cleaner technologies to their trading partners, thus minimising environmental pollution. TO, on the other hand, is expected to have a negative sign where cleaner products are imported from the country's trading partners. Similar to TO, FD in ASEAN-3 nations could also have an expected negative sign on carbon emissions. The level of corruption (COR) and UPOP may have a positive sign as found by previous studies on ASEAN countries. The autoregressive distributed lag (ARDL) model based on the unrestricted error correction model (UECM) is presented below:

$$\begin{aligned} \Delta LNCO_{2t} = & \beta_0 + \theta_0 LNCO_{2t-1} + \theta_1 LNGDP_{t-1} + \theta_2 LNENY_{t-1} \\ & + \theta_3 LNFDI_{t-1} + \theta_4 LNTOT_{t-1} + \theta_5 LNFD_{t-1} + \theta_6 LNCOR_{t-1} \\ & + \theta_7 LNUPOP_{t-1} + \sum_{i=1}^a \beta_i \Delta LNCO_{2t-i} + \sum_{i=0}^b \gamma_i \Delta LNGDP_{t-i} \\ & + \sum_{i=0}^c \delta_i \Delta LNENY_{t-i} + \sum_{i=0}^d \lambda_i \Delta LNFDI_{t-i} + \sum_{i=0}^e \theta_i \Delta LNTOT_{t-i} \\ & + \sum_{i=0}^f \psi_i \Delta LNFD_{t-i} + \sum_{i=0}^g \kappa_i \Delta LNCOR_{t-i} + \sum_{i=0}^h \Omega_i LNUPOP_{t-i} + v_t \end{aligned} \quad (3.0)$$

Where Δ here toregressive distributed lag (ARDL) is the white-noise disturbance term. Residuals for the UECM were serially uncorrelated and the model was stable. The final model represented in Equation (3.0) above could also be viewed as an ARDL of order (a, b, c, d, e, f, g, h). The model indicated that the level of carbon emissions (LNCO₂) could have been influenced and explained by its past values, so it involved other disturbances or shocks. From the estimation of UECM, the long-run elasticity was the coefficient of the one lagged explanatory variable (multiplied by a negative sign) divided by the coefficient of the one lagged dependent variable. The short-run effects were captured by the coefficients of the first differenced variables. The null of no cointegration in the long-run relationship is defined by: $H_0: \theta_0 = \theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = \theta_6 = \theta_7 = 0$ (there is no long-run relationship), and is tested against the alternative of: $\theta_1: \theta_0 \neq \theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4 \neq \theta_5 \neq \theta_6 \neq \theta_7 \neq 0$ (a long-run relationship exists), by means of the familiar F-test. If the computed F-statistic is less than the lower bound critical value, then the null hypothesis of no cointegration is not rejected. However, if the computed F-statistic is greater than the upper bound critical value of at least 10% significance level, then the null hypothesis of no cointegration is rejected.

This study has used annual data ranging from 1970 up to 2017 (48 years) as a sample period. A summary of the data and its sources is displayed in Table 1.

4. ANALYSIS

The Augmented Dickey-Fuller (ADF) and Phillip-Perron (PP) tests are the two most common unit root tests used to trace the stationarity of each variable in such studies. These tests are important at the preliminary stage for time series analysis as researchers can identify the suitable cointegration tests for their proposed econometric models. Based on the outcomes of the unit root tests as reported in Table 2 below, it was found that there

Table 1: Sources of data

| Variable | Description | Source |
|-----------------|---|--------|
| CO ₂ | Carbon emissions (metric tonnes per capita) | WDI |
| GDP | GDP per capita (constant, 2010) | WDI |
| ENY | Energy consumption (kg oil equivalent per capita) | WDI |
| FDI | Foreign direct investment, net inflows (% of GDP) | WDI |
| TO | Trade (% of GDP) | WDI |
| FD | Broad money, M2 (% of GDP) | WDI |
| COR | Corruption perception index | ICRG |
| UPOP | Urban population (% of total population) | WDI |

WDI stands for World Development Indicators (2018) and ICRG stands for International Country. Risk Guide (2017)

Table 2: Results of ADF and PP unit root tests

| Country | Stage | Variable | ADF unit root test | | PP unit root test | |
|-----------------|------------------|-------------------|--------------------|---------------------|-------------------|---------------------|
| | | | Intercept | Trend and intercept | Intercept | Trend and intercept |
| Malaysia | Level | LNCO ₂ | -1.721 | -1.489 | -1.744 | -1.489 |
| | | LNGDP | -0.522 | -1.618 | -0.534 | -1.825 |
| | | LNENY | -1.226 | -1.647 | -1.761 | -1.563 |
| | | LNFDI | -3.122** | -4.032** | -3.005** | -4.006** |
| | | LNTO | -1.798 | -0.358 | -1.643 | 0.620 |
| | | LNFD | -5.930*** | -5.154*** | -2.321 | -2.224 |
| | | LNCOR | -1.580 | -1.575 | -1.575 | -1.780 |
| | | LNUPOP | 1.243 | -1.991 | 0.944 | -1.989 |
| | First difference | LNCO ₂ | -5.427*** | -5.708*** | -5.428*** | -5.705*** |
| | | LNGDP | -4.810*** | -4.806*** | -4.804*** | -4.798*** |
| | | LNENY | -4.411*** | -4.618*** | -6.048*** | -12.678*** |
| | | LNFDI | -6.355*** | -5.678*** | -14.912*** | -26.088*** |
| | | LNTO | -3.242** | -5.143*** | -3.249** | -6.416*** |
| | | LNFD | -5.389*** | -5.304*** | -5.396*** | -5.304*** |
| | | LNCOR | -5.632*** | -5.801*** | -5.647*** | -5.799*** |
| | | LNUPOP | -4.140*** | -5.425*** | -4.140*** | -4.676*** |
| Indonesia | Level | LNCO ₂ | -1.109 | -3.567** | -0.974 | -0.974 |
| | | LNGDP | -0.004 | -2.209 | -0.004 | -1.729 |
| | | LNENY | -1.928 | -1.852 | -4.059*** | -1.687 |
| | | LNFDI | -1.971 | -1.916 | -2.225 | -2.203 |
| | | LNTO | -2.510 | -2.345 | -2.457 | -2.226 |
| | | LNFD | -1.930 | -1.930 | -2.123 | -2.060 |
| | | LNCOR | -1.367 | -1.887 | -1.687 | -2.280 |
| | | LNUPOP | -2.298 | -1.335 | -6.472*** | -0.024 |
| | First difference | LNCO ₂ | -5.246*** | -5.223*** | -9.860*** | -10.436*** |
| | | LNGDP | -4.147*** | -4.069** | -1.729*** | -4.055** |
| | | LNENY | -5.909*** | -6.356*** | -5.908*** | -7.372*** |
| | | LNFDI | -4.211*** | -4.132** | -4.189*** | -4.111** |
| | | LNTO | -7.812*** | -8.039*** | -7.953*** | -8.833*** |
| | | LNFD | -4.111*** | -4.053** | -4.088*** | -4.031** |
| | | LNCOR | -3.891*** | -3.824** | -3.904*** | -3.839** |
| | | LNUPOP | -0.463 | -1.936886 | -0.463 | -2.000 |
| The Philippines | Level | LNCO ₂ | -1.372 | -1.638 | -1.372 | -1.636 |
| | | LNGDP | 2.806 | -1.591 | 4.189 | -1.635 |
| | | LNENY | -2.310 | -2.448 | -1.880 | -1.859 |
| | | LNFDI | -4.357*** | -4.075** | -10.563*** | -6.981*** |
| | | LNTO | -1.538 | -0.818 | -1.602 | -0.857 |
| | | LNFD | -1.821 | -2.186 | -1.217 | -1.905 |
| | | LNCOR | -13.634*** | -13.026*** | -7.054*** | -7.173*** |
| | | LNUPOP | -2.382 | -4.363*** | -2.487 | -7.134*** |
| | First difference | LNCO ₂ | -5.767*** | -5.824*** | -5.763*** | -5.829*** |
| | | LNGDP | -5.699*** | -6.485*** | -5.453*** | -6.386*** |
| | | LNENY | -2.640* | -2.708 | -6.255*** | -6.225*** |
| | | LNFDI | -6.186*** | -6.384*** | -6.170 | -6.351*** |
| | | LNTO | -4.280*** | -5.221*** | -4.392*** | -5.221*** |
| | | LNFD | -3.539** | -3.452* | -3.539** | -3.452* |
| | | LNCOR | -5.197*** | -5.683*** | -5.204*** | -5.683*** |
| | | LNUPOP | -2.355 | -1.402 | -2.411 | -1.182 |

**** and * represent 1%, 5% and 10% significance levels, respectively. 2. The optimal lag has been selected using the Schwarz information criterion for ADF tests and the bandwidth has been selected using the Newey-West method for the PP test

was mixed stationary evidence of I(0) and I(1) both at level and at first difference for all models from the three ASEAN countries. For example, for Malaysia, LNFDI and LNFD, LNENY and LNUPOP and LNFDI and LNCOR were found to be stationary even at level, both at intercept and trend and intercept. Meanwhile, most variables were found to be stationary after being converted into first difference while some variables such as LNUPOP for Indonesia and LNENY and LNUPOP for the Philippines were found to be non-stationary. The mixed stationarity of the data at I(0) and I(1) fulfilled the condition of bound cointegration to test for short-run and long-run elasticities.

The outcomes of ARDL long-run cointegration for each ASEAN-3 country are displayed in Table 3. This procedure is an important stage and needs to be conducted before the outcomes of short- and long-run elasticities can be discussed. To ensure that long-run cointegration existed in each country, the F-statistic had to be at least greater than the upper bound value of 10% significance level. All the countries were found to prove the existence of long-run cointegration, given that their F-statistic values exceeded the 1% significance level.

To ensure accurate results, it is important that every single model is free from any diagnostic problems. Table 4 reveals the results

Table 3: Results of ARDL cointegration

| ASEAN-3 | Maximum lag | Lag order (p, q, r, s, t, u, v) | F-statistic | Result |
|---|-------------|---------------------------------|-------------|-----------------|
| Malaysia | (2,2) | (1, 2, 0, 2, 0, 0, 1, 2) | 4.625*** | Long run exists |
| Indonesia | (2,2) | (2, 1, 0, 0, 2, 0, 0, 0) | 3.969** | Long run exists |
| The Philippines | (2,2) | (1, 0, 2, 2, 1, 2, 2, 1) | 8.432*** | Long run exists |
| Critical values for F-statistics [#] | | | Lower | Upper I (1) |
| 1% | | | 1 (0) | |
| 5% | | | 2.96 | 4.26 |
| 10% | | | 2.32 | 3.5 |
| | | | 2.03 | 3.13 |

1. [#]The critical values are obtained from Pesaran et al. (2001) based on Case III: Unrestricted intercept and no trend. 2. *** and ** represent 10%, 5% and 1% levels of significance, respectively

Table 4: Results of diagnostic checking

| ASEAN-3 | Serial correlation $\chi^2 (1)$ [P-value] | Functional form $\chi^2 (1)$ [P-value] | Normality $\chi^2 (2)$ [P-value] | Heteroscedasticity $\chi^2 (1)$ [P-value] |
|-----------------|---|--|--|---|
| Malaysia | 0.425 [0.662] | 0.022 [0.883] | 4.219 [0.121] | 0.477 [0.918] |
| Indonesia | 0.1339 [0.718] | 2.793 [0.113] | 6.454 [0.039] | 0.5288 [0.868] |
| The Philippines | 2.517 [0.130] | 0.056 [0.816] | 0.472 [0.789] | 1.191 [0.386] |

The numbers in brackets [] are P values

of diagnostic checking for each ASEAN-3 country. Four different types of diagnostic tests were utilised: Serial correlation, functional form, normality and heteroscedasticity tests. The null hypothesis of each test indicated the non-existence of all diagnostic problems while the alternative hypothesis indicated the existence of the problems. Given that the probability value of each test for each country was larger than 10% significance level, they failed to reject the null hypothesis, thus confirming that all models were free from any diagnostic problems.

The stability of the models was also tested using the cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ) tests as part of diagnostic checking. A model is considered stable if the plot (blue line) falls inside the critical bounds (the dotted red line) of 5% significance level. All the diagrams, as displayed in Figure 3, presented their plots within the critical bounds, except for the CUSUMSQ for Indonesia and the Philippines. Despite the plots seeming to bypass the critical bound, the plots were also moving back towards this area, thus these models were still considered as stable as the rest of the models.

The outcomes of both short-run and long-run elasticities are revealed in Table 5. Attention was only given to lag 0 for the outcomes of short-run elasticities for each variable. The results have been explained below according to each country's outcomes.

4.1. Malaysia

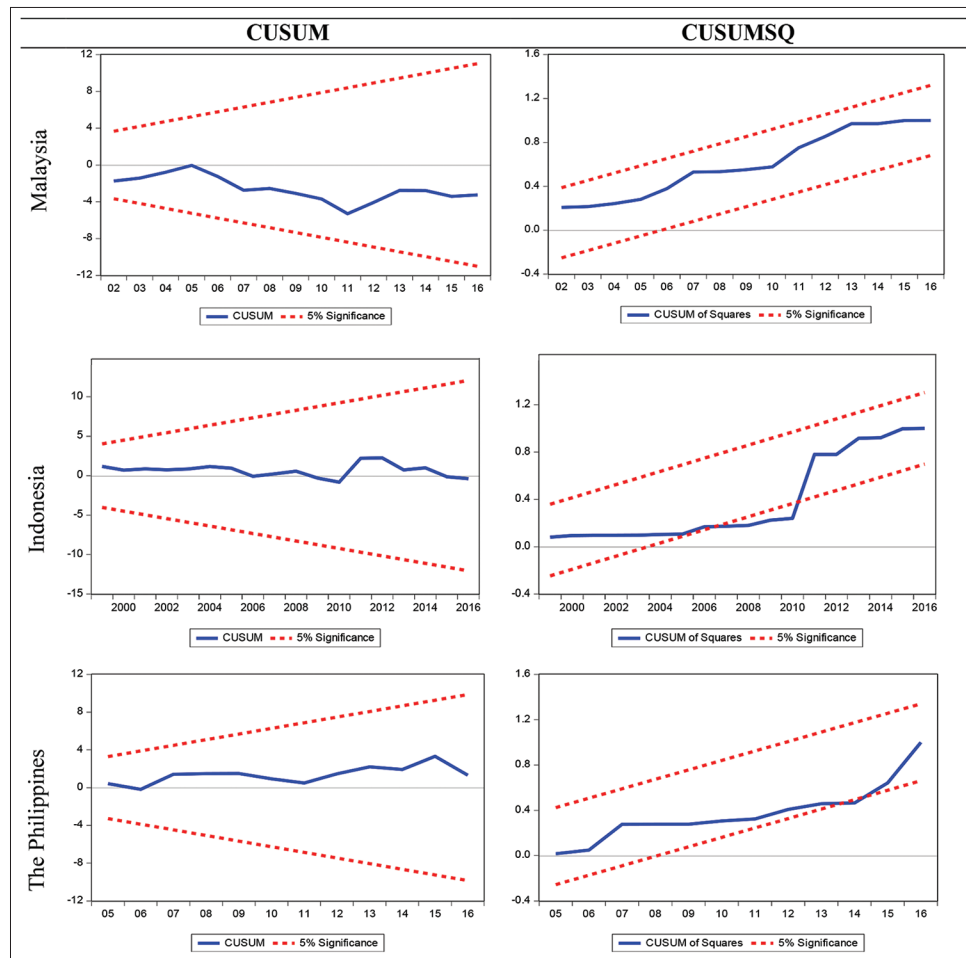
The short-run and long-run elasticity outcomes indicated that a higher level of economic growth (LNGDP) has led towards higher environmental pollution in Malaysia. Statistically, a 1% increase in LNGDP has increased the level of carbon emissions (LNCO₂) by 1.597% in the short run and 0.863% in the long run. The reduction of carbon emission releases in the long run has revealed

Table 5: Estimation of short-run and long-run elasticities

| Country/ARDL | Malaysia (1, 2, 0, 2, 0, 0, 1, 2) | Indonesia (2, 1, 0, 0, 2, 0, 0, 0) | The Philippines (1, 0, 2, 2, 1, 2, 2, 1) |
|-------------------------------|---|--|--|
| Short-run elasticities | | | |
| ΔLNCO_2 | - | - | - |
| $\Delta \text{LNCO}_{2(-1)}$ | - | 0.341* | - |
| ΔLNGDP | 1.597*** | 1.264 | 0.069** |
| $\Delta \text{LNGDP}_{(-1)}$ | 1.139*** | - | - |
| ΔLNENY | -0.087 | -0.401 | 0.906** |
| $\Delta \text{LNENY}_{(-1)}$ | - | - | 0.697** |
| ΔLNFDI | -0.036** | -0.07 | -0.059*** |
| $\Delta \text{LNFDI}_{(-1)}$ | 0.020* | - | 0.041** |
| ΔLNTO | 0.352** | -0.140 | -0.376** |
| $\Delta \text{LNTO}_{(-1)}$ | - | 0.671*** | - |
| ΔLNFD | 0.159* | 0.347 | 0.439** |
| $\Delta \text{LNFD}_{(-1)}$ | - | - | -0.381* |
| ΔLNCOR | 0.074 | 0.182** | -0.095 |
| $\Delta \text{LNCOR}_{(-1)}$ | - | - | -0.116*** |
| ΔLNUPOP | -0.334 | 2.537** | -1.758* |
| $\Delta \text{LNUPOP}_{(-1)}$ | 0.557** | - | - |
| Long-run elasticities | | | |
| LNGDP | 0.863*** | -1.168 | 0.051 |
| LNENY | -0.091 | -0.560 | 0.055 |
| LNFDI | -0.108*** | -0.098 | -0.124*** |
| LNTO | 0.368** | -1.452* | -0.371** |
| LNFD | 0.166* | 0.485 | 1.045*** |
| LNCOR | 0.632** | 0.255** | 0.115*** |
| LNUPOP | -0.723* | 3.543** | 0.770** |
| Constant | -7.572*** | 3.527 | -4.026* |
| ECT | -0.956*** | -0.715*** | -1.363*** |

1. Dependent variable is ΔLNGINI . 2. *** and ** indicate significance at 10%, 5% and 1% significance levels, respectively. 3. The ARDL estimation outcomes are generated using SIC

that the Malaysian government has been trying its best to cope with environmental pollution issues through the enforcement of stricter laws for industries. Besides LNGDP, it was also shown

Figure 3: CUSUM and CUSUMSQ stability tests

that increasing financial development (LNFD), both in the short run and in the long run, has worsened the environmental quality in the country. Statistically, a 1% increase in LNFD has increased the LNCO_2 by 0.159% in the short run and 0.632% in the long run, respectively. It is speculated that the financial institutions in the country might have provided more credit access to many of the industries involved in manufacturing and that most of these industries still rely on polluting energy resources such as coal and fuel for their production activities. The level of foreign investment inflows (LNFDI) recorded a negative sign, both in the short run and in the long run, which indicated that the higher level of investment in the country has helped to reduce the level of carbon emissions (LNCO_2). Statistically, a 1% increase in LNFDI has reduced LNCO_2 by 0.036% in the short run and 0.108% in the long run. The multinational corporations (MNCs) that have invested in the country might be transferring more environmentally friendly technologies, which has led towards a reduction in carbon emission releases. This finding has been supported by a previous study by Al-Mulali and Tang (2013) in the Gulf Cooperation Council countries and by Tang and Tan (2015) in Vietnam. Another variable that improved the level of environmental quantity in the long run was the level of urbanisation (LNUPOP). Statistically, a 1% increase in LNUPOP has reduced LNCO_2 by 0.723%. In developed cities, the urbanised population prefers to use energy-efficient appliances as they reduce the cost of energy usage. As more people switch to environmentally friendly products, it also

helps a country mitigate the issue of environmental pollution. The rest of the potential indicators, such as trade openness (LNT0) and level of corruption (LNCOR), were found to have positive signs and significant coefficients. Overall, 1% increases in LNT0 and LNCOR have led to 0.368% and 0.632% increases in LNCO_2 . These results were similar to the findings of Chang (2015) who stated that countries with high levels of corruption experience higher environmental degradation through TO, while it decreases in countries with low corruption levels. As seen in recent media releases, reporters have revealed that Malaysia has become a haven for dumping waste from China, Australia, New Zealand and other countries and this problem could be related to the problem of corruption that is occurring in the country.

4.2. Indonesia

Based on the lag 0 of the short-run elasticities, it was found that LNCOR and LNUPOP had a positive relationship with LNCO_2 . Higher levels of LNCOR and LNUPOP have caused greater environmental pollution in the nation. Statistically, a 1% increase in LNCOR and LNUPOP has led to 0.671% and 2.537% increases in LNCO_2 . Meanwhile, in the long run, it was found that only LNT0 had a negative and significant relationship with LNCO_2 . These results were similar to past studies conducted by Shahbaz et al. (2013) for Indonesia. According to Sbia et al. (2014), a broadening in trade openness increases the flow of new technology, which replaces the old technology that has been heavily consuming

energy. In recent years, Indonesia has aggressively increased its bilateral trade activities with Japan, South Korea and Singapore and the country has become one of the top destinations for investment in the ASEAN region. The government has actively introduced attractive benefits for its trading partners in order to increase bilateral trade. The other tested variables such as LNCOR and LNUPOP were found to have significant and positive signs, thus confirming that the higher level of corruption (LNCOR) and urban population (LNUPOP) have caused higher releases of carbon emissions into the air. Statistically, a 1% increase in LNCOR and LNUPOP has caused 0.255% and 3.543% increases in air pollution. These results have indicated issues that could disrupt the country's progress towards achieving its goal of sustainable development. The goal could also be harder to achieve as the level of corruption has spread across the nation, which has allowed more polluting industries to carry on their operations without being blacklisted by the authorities. Additionally, this empirical exercise has indicated that LNUPOP has been a major contributor to CO₂ emissions in Indonesia. The increasing urban population has caused more damage to environmental quality as the government may be less concerned about environmental issues when it comes to developing urban areas.

4.3. The Philippines

All short-run coefficients were found to be significant and have influenced the level of carbon emissions in the case of the Philippines, except for LNCOR. Positive signs were detected for LNGDP, LNNY and LNFD, while negative signs were detected for LNFDI, LNTD and LNUPOP. The increase in the country's economic development and higher energy consumption have only worsened the environmental quality in the country in the short run. However, these factors have failed to influence carbon emissions in the long run. Statistically, 1% increases in LNGDP and LNNY have increased carbon emission releases by 0.069% and 0.906%, respectively. Nevertheless, increasing LNFDI and LNTD have helped to curb the rise of carbon emission releases not only in the short run but also in the long run. Based on the long-run elasticities, a 1% increase in both LNFDI and LNTD has reduced carbon emissions by 0.124% and 0.371%, respectively. A higher level of foreign direct investment and expanding trade openness have benefited the country through the transfer of cleaner technologies from its trading partners such as Japan and South Korea. According to List and Co (2000), inflows of FDI help to promote the energy efficiency of the host countries and cut carbon emissions. In addition, Tamazian et al. (2009) have reported that FDI helps enterprises to promote technology innovation and adopt new technologies, thus increasing energy efficiency and advancing low-carbon economic growth. Meanwhile, LNFD, LNCOR and LNUPOP have shown a positive and significant relationship to LNCO₂. The increases in these three variables have worsened the environmental quality by 1.045%, 0.115% and 0.770%, respectively. Similar to the Malaysian and Indonesian outcomes, corruption rates at the authority level have caused the country to experience more illegal factory activities that have led to higher environmental pollution. These activities might be due to poor enforcement of environmental regulations, as explained by Aklin et al. (2014) and Welsch (2004). Furthermore, the growing number of financial institutions in the Philippines

could mean higher credit accessibility for these businesses to run their unauthorised operations. Lastly, intensive urban growth in a high-density population country such as the Philippines can lead to highly concentrated energy use, thus leading to greater air pollution.

4.4. Error Correction Term (ECT) Outcomes

As depicted in Table 5, the estimated lagged ECT in ARDL regression for the three developing ASEAN countries was negative and statistically significant. Based on the ECT value, the highest speed of adjustment was obtained by the Philippines (-1.363), followed by Malaysia (-0.956) and Indonesia (-0.715). For example, more than 136%, 95% and 71% of adjustments were completed within less than a year in the Philippines, whereas it was a year for Malaysia and Indonesia due to short-run adjustments, which is considered very rapid.

5. CONCLUSIONS AND POLICY RECOMMENDATIONS

The main objectives of this research paper were to investigate the impact of corruption rates and other probable economic indicators, such as energy consumption, foreign direct investment inflows, trade openness, financial development and urban population, on the level of environmental quality for Malaysia, Indonesia and the Philippines. The long-run outcomes have confirmed that higher levels of corruption in all ASEAN-3 developing countries have caused higher environmental pollution. One example has been the recent media exposes of illegal waste dumping and illegal business activities relating to waste imports from the US, Australia, New Zealand, China, etc.

To alleviate environmental pollution, it is important for the governments of these countries to enforce stricter laws and impose heavier penalties on illegal firms that engage in open burning or dumping activities. Besides these measures, any official involved in bribery activities, such as approving permits for illegal firms to carry out their unlawful operations, should be dismissed from their job. Increasing trade openness has led to higher environmental pollution in the case of Malaysia. Thus, there is a need for the government of Malaysia to adequately monitor and police the illegal trade of plastic waste, which has been heavily imported into the country. Meanwhile, inflows of FDI have led to lower environmental pollution in the ASEAN-3 countries. Therefore, it is important for policymakers to continue to offer more benefits to MNCs, such as tax concessions, for the first few years of operation and to target more investment from companies that are willing to transfer their cleaner and more efficient technology knowledge. Policymakers should also pay more attention to the lending power of the financial sector by regularly assessing the environmental performance of industries, given that most of the emission releases in the three ASEAN countries, including carbon dioxide, have been related to the financial development variable. Finally, the findings on urbanisation and its relationship with environmental pollution have an important reference value, particularly for the Indonesian and the Philippines governments, as the outcomes have illustrated the urgency of developing long-term urbanisation development

policies and effectively addressing the issues of environmental degradation.

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