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Role of Financial Development, Economic Growth & Foreign Direct Investment in Driving Climate Change: A Case of Emerging ASEAN

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Abstract: In the context of remarkable economic growth and financial development in the emerging economies of East Asia, this paper attempts to shed light on the ecological consequences (CO₂ emission) of economic growth, foreign direct investment (FDI) and financial development in the selected ASEAN-5 economies. Drawing on the data from 1982 to 2014, we employed a set of quantitative techniques for panel data analysis which entailed Dynamic Ordinary Least Squares (DOLS) and Fully Modified OLS (FMOLS) approaches. Our findings indicate that financial and economic development, as well as FDI, have a statistically significant long-run co-integrating relationship with environmental degradation (CO₂ emissions) in the under-analysis economies. It showed that in ASEAN-5 countries, economic growth, financial development and FDI leads to an increase in environmental degradation. The quadratic term for economic growth showed a negative impact on environmental degradation i.e. Environmental Kuznets Curve (EKC). Our key findings manifest and emphasise the importance of appropriate policies for more inclusive economic and financial development and sustainable foreign direct investment which does not impede on the environment.

JEL Classification : F14, F15, F43, E31, Q41, Q43

Keywords: ASEAN, Economic Growth, Pollution Heavens Hypothesis (PHH), Environmental Kuznets Curve (EKC), Emerging Economies, Financial Development, FDI, CO₂ emission, FMOLS, DOLS.

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1. Introduction

The 21st Century is marked as the Asian Century and a manifestation of this is prima evident in the fact that the emerging economies of Asia have been shouldering the global growth since the Global Financial Crisis of 2008. In this regard, the Association of Southeast Asian Nations (ASEAN) has appeared as a significant economic block. As it stands, the ASEAN Economic Community (AEC) comes as a market of over US\$ 2.6 trillion and a population of over 622 million growing at an impressive growth rate of around 5.2 and 4.9% in the second and third quarters of 2018 (FocusEconomics, 2018). Nonetheless, the forecast shows steady growth ahead for the AEC. In fact, according to the McKinsey Global Institute (MGI) report, ASEAN economies are among the world's outperforming emerging economies with a positive prospect of long-term growth (Das and Lin, 2018). While the economic growth and social progress in the ASEAN region are commendable, it is important to consider the ecological and environmental consequences of it. The literature on the economic growth and environmental degradation is mixed and the focus of a number of studies has been on the contrast between the short and long terms consequences of the economic growth. Specifically, the notion that despite degradation of the environment in the short-run the economic growth can improve the environmental quality in the long-run. A phenomenon often referred as the Environmental Kuznets Curve (EKC)². However, the empirical evidence on this aspect of economic growth and environment entails mixed findings. For instance, Lindmark (2002), Lantz and Feng (2002), Caviglia-Harris et al (2009), Narayan and Narayan (2010), Song et al (2013), Onafowora and Owoye's (2014), Apergis (2016) and Atasoy (2017) report contrasting results in different countries. One may argue that there could be differences between the developed and developing countries, yet such an assertion would be oversimplification as the empirical evidence suggests that there are considerable differences even within the developed and developing countries (see, Al-Mulali and Ozturk (2016), Özokcu and Özdemir (2017) and Shahbaz et al (2018). Concomitantly, it requires one to conduct an analysis specific to the economies in question before one can draw a conclusion as to the ecological and environmental consequences of economic growth in the ASEAN region.

Parallel to the economic growth, a crucial aspect is the growth of the financial sector or financial development. In fact, the economic and financial growth and stability are logically and legitimately

² See, Grossman and Krueger (1991) and Shafik (1994) among the initial contributors.

perceived to be *two side of a coin* (Borio, 2011 and Nasir et al, 2015). The importance of the financial sector for the real economy has been magnified by the Global Financial Crisis of 2008. Although the nexus between the financial and economic stability has been emphasised long ago by various scholars (Bagehot, 1873, Gurley and Shaw (1960), Goldsmith (1969), McKinnon (1973) and Shaw (1973) and Minsky (1974, 1982) Kindleberger, 1978) the GFC revived and reignited the debate on the role of financial development in the economic growth and development (Borio, 2011; Nasir et al 2015). Concomitantly, some scholars argued that the role of the financial sector in the economy should be seen in a more holistic manner (Beck, 2012, Nguyen et al 2017). There is also an important ecological aspect of finance (Grafton et al 2004; Campiglio, 2016; Ackerman, 2017; Leimbach et al 2018; Richardson, 2018; Yuan and Gallagher, 2018). Despite the recognition of financial development as an important factor for the economic growth it is also vital to consider this nexus more broadly and bring into account the social and ecological consequences of financial development which is one of the aspect the subject study is focusing on, specifically in the context of ASEAN region.

Similar to the literature on the finance-growth nexus, the literature on the role of finance in environmental degradation or improvement is also interesting but contrasting and hence inconclusive (see for instance, Tamazian and Rao, 2010; Ozturk and Acaravci, 2013; Shahbaz et al., 2016a, 2016b; Bekhet et al., 2017; Salahuddin et al., 2018). On this aspect, Zhang (2001) argued that the nexus between financial development and energy consumption can be explained by three channels. According to the first channel, the financial development results in the increase in the FDI and economic growth which consequently leads to an increase in the consumption of energy. Secondly, there is an increase in the credit creation due to efficient financial intermediation which leads to an increase in the usage of energy-intensive goods and services. In the third channel, financial development leads to more investment which also increases the consumption of energy and hence, environmental degradation (Zhang, 2011). Concomitantly, it is worth acknowledging that the finance-environment nexus the finance-led economic growth plays a crucial part. As the evident on the finance-growth nexus suggests that the financial development is a major catalyst of economic growth (Soukhakian, B. (2007), Soukhakian, N. (2007), Katircioglu, 2012), it intuitive to expect that this may have ecological implications. Specifically, real income growth as results of financial development which leads to additional energy demand and investment in energy sector which then affects environment (Katircioglu and Taspinar (2017) and Cetin and Ecevit (2017). On

the positive side, in a later study, Chang (2015) argued that financial development may offer more opportunities to develop the renewable energy sector by providing more funds to innovative firms. Nonetheless, the technological innovation and efficiency accompanied by FDI can help to reduce the energy consumption. However, we are to see which channel of financial development rolls the roost and specially, whether the financial development leads to improvement or degradation of environment in the under analysis ASEAN region. Nonetheless, we are employing a more inclusive approach to measure the financial development and structure by incorporating not only the credit creation but also the development of equity market and international indebtedness of the underlying economies.

The overarching evidence on the FDI role in environmental degradation is also inconclusive and contrasting. This inconclusiveness and contrast is a manifestation of the fact that theoretically there are three key dimensions of the nexus between FDI and environmental degradation. These include pollution-haven, pollution-halo and scale-effect hypothesis. According to the pollution-haven hypothesis the inwards FDI attracted by the weak regulatory environment in the host country leads to degradation of the environment (Cole and Fredriksson 2009; Naughton, 2014). On the contrary, the pollution-halo hypothesis suggests that FDI by the multinational and transnational enterprises leads to the application of global environmental practices and standards in the host country as well as the transfer of green technology. In a nutshell, whether the FDI decreases or increases the environmental degradation is contingent on whether pollution-haven or pollution-halo factor dominates. Nonetheless, the third aspect of FDI that is scale-effect hypothesis is also too important to condone. In this channel, the FDI leads to a significant increase in the industrial output of the host country which leads to an increase in the pollution and environmental degradations (Pao and Tsai, 2011, Rezza, 2013). Given that the ASEAN countries have been attracting huge influx of FDI and along with the substantial economic growth, the financial sector have also been going through growth and development, it is intriguing to investigate the ecological consequences of these factors. The recent estimates suggest that the FDI flows to the ASEAN have been continuously increasing each year reaching an all-time high of US\$137 billion in 2018 and are also expected to reach US\$200 by 2025 (ASEAN Investment Report, 2018). Keeping this in context, we aimed to analyse the implication of economic growth, FDI and financial development for environmental degradation in ASEAN countries while drawing on the empirical data from 1982 to 2014. In terms of originality and contribution to the existing evidence and debate on the subject,

the subject study has a) analysed the ecological and environmental implications of rapid economic growth in the ASEAN region, in both short and long run by exploring the aspect of EKC b) the subject study has analysed the ecological and environmental implications of financial development for the ASEAN region while employing a more inclusive approach to financial development which entailed three dimension of financial development and c) the study analyse the ecological and environmental implication of FDI for the ASEAN region which has experienced an unrepresented influx of FDI in the recent years. In so doing, we employed a set of quantitative techniques for panel data spanning from 1982 to 2014, including Dynamic Ordinary Least Squares (OLS) (DOLS) and Fully Modified OLS (FMOLS) approaches. Our findings indicate that financial and economic development as well as FDI have a statistically significant long-run co-integrating relationship with environmental degradation (CO^2 emissions) in the under analysis economies. It showed that the in ASEAN-5 countries, the economic growth, financial development and FDI leads to an increase in the environmental degradation. The quadratic term for economic growth showed a negative impact on the environmental degradation i.e. Environmental Kuznets Curve (EKC). Our key findings manifest and emphasise the importance of appropriate policies for more inclusive economic and financial development and sustainable foreign direct investment which does not harbour adverse ecological consequences for the ASEAN economies.

The result of the paper proceeds as follows, in section 2 we briefly reflect and acknowledge the existing evidence on the subject. Section 3 presents the empirical framework and dataset, Section 4 will present the empirical findings which will lead to the conclusion in section 5.

2. Literature Review

This study is focusing on the ecological implication of economic growth, financial development and FDI, concomitantly, for the sake of coherence we can divide the literature into three aspects. To start with we look at the evidence on the economic growth and environmental degradation.

2.1 Economic Growth and Environment Nexus

Economic growth is one of the prime objectives of macroeconomic policymaking, particularly since the WWII (Raworth, 2017). The same holds true for the ASEAN economies. Yet, an important aspect which gained global attention in the last few decades is the ecological consequences of economic growth. On this aspect, a number of studies investigated the impact of economic growth on environmental degradation and often focused on the notion of the

Environmental Kuznets Curve (EKC). According to the EKC, there is an inverted U-shaped relationship between economic growth and environmental degradation and hence, in the short-run, the economic growth contributes to the degradation of the environment, however as the countries reach the higher level of income this relationship goes inverse and economic growth starts to have a positive impact on the environment. Following the initial contribution on the nexus between economic and environment in the context of EKC by Grossman and Krueger (1991) and Shafik (1994), a number of studies have empirically tested this nexus. For example, in their study on the UK, Fosten et al. (2012) reported significant evidence of EKC. Furthermore, they found an asymmetric adjustment of temporary disequilibrium from the long-run EKC which they associated with the presence of strong environmental regulation in the UK. Perhaps, this is an aspect which could be of interest to the emerging economies such as ASEAN. In another study, Esteve and Tamarit (2012) focusing on the Spanish data argued that although the EKC may not follow a strict inverted U-shaped pattern, there is evidence that in the long run, the economic growth leads to a reduction of CO₂ emissions and hence environmental improvements. However, in a later study which was also focusing on Spain, Sephton and Mann (2013) argued that in fact there is a long-run non-linear attractor that draws emissions and per capita income together and there is also an asymmetric adjustment. Similarly, Tiwari et al. (2013) and Sinha and Shahbaz (2018) reported a short as well as a long-run relationship between economic growth and environmental degradation. However, on the contrary, while focusing on the Indian economy Gosh (2010) reported lack of evidence on the existence of a long run relationship between economic growth and emission. Similarly, Pal and Mitra (2017) analysing Indian as well Chinese data failed to find a significant evidence of EKC, yet on the contrary, Brajer et al (2008) reported significant evidence of EKC in China. There is also a strand of literature which focused on multiple countries. For instance, employing the data of 15 OECD countries³, Apergis (2016) reported that although there was overarching evidence of EKC, however, it was not the case in all of the countries. Similarly in a study by Sinha et al (2017) reported the presence of rather an N-shaped EKC in N-11 countries⁴. In another study which drew on the panel data from 27 developed countries, Al-Mulali and Ozturk (2016) reported significant evidence of EKC relationship. Similarly, in a study on Arctic countries,

³ These include 14 European countries i.e. Austria, Belgium, Canada, Denmark, Finland, France, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and UK and USA.

⁴ N-11 or Next 11 includes Bangladesh, Egypt, Indonesia, Iran, Mexico, Nigeria, Pakistan, the Philippines, Turkey, South Korea, and Vietnam.

Baek (2015) reported that there was very little evidence of the existence of the EKC in the Arctic countries. In another remarkable study, Onafowora and Owoye's (2014) analysed the notion of EKC in the selected economies of Brazil, China, Egypt, Japan, Mexico, Nigeria, South Korea, and South Africa indicate. However, they could only find the evidence of EKC in Japan and South Korea which were the only developed countries in their dataset. The led Shahbaz et al (2018) argued that the stage of the development of a country may also influence the presence of EKC. However, a study by Narayan and Narayan (2010) focusing on 43 developing countries reported although there was evidence of EKC in the South Asian and Middle Eastern countries, on the whole, there were mixed and contrasting results. This implies that there could be regional heterogeneities as well and hence, one size does not fit all. Perhaps comprehensive studies by Caviglia-Harris et al (2009) on 40 countries and Özokcu and Özdemir (2017) on 52 developing and 26 OECD countries, reported that there is no significant evidence of EKC. They argued that continued economic growth cannot lead to environmental improvement. Similarly, in the most recent studies, Shahbaz and Sinha (2019) conducted an inclusive survey of literate and concluded that the results of EKC are inconclusive and are contingent on the contexts, time period, explanatory factors and choice of empirical approach. These findings are of profound importance for the ASEAN countries and particularly in the context of the remarkable growth they have achieved and projected to achieve in the year ahead.

2.2 Financial Development and Environment Nexus

Financial stability is vital for economic stability and by the same logic, a well-functioning and efficient financial sector facilitates economic growth. (Soukhakian, B. (2007), Soukhakian, N. (2007), Katircioglu, 2012), it intuitive to expect that this may have ecological implications. However, the positive role of financial sector development in enhancing economic growth can also increase the consumption of energy and concomitantly have unintended ecological consequences (Sadorsky, 2010, 2011; Shahbaz et al., 2012a, 2012b; Shahbaz et al., 2013c; Islam et al., 2013; Shahbaz et al., 2017c, Katircioglu and Taspinar, 2017; Cetin and Ecevit, 2017; Shahbaz et al 2018). The empirical evidence on the nexus between financial development and environmental degradation is mixed and contrasting. For instance, there are also a number of studies which suggest that the financial sector development can improve environmental quality. Among the earlier contributors, Tamazian et al. (2009) analysing the BRICS economies reported that financial

development can reduce environmental degradation. Similarly, in their study focusing on 24 transition economies, Tamazian and Rao (2010) reported that financial liberalisation can lead to lowering CO₂ emissions and hence improves environmental quality. Later, studies by Jalil and Feridun (2011) on China, Shahbaz et al. (2013c) on Malaysia and South Africa, Abbasi and Riaz (2016) on Pakistan, Dogan and Seker (2016) on top countries listed in the renewable energy attractiveness index and most recently Shahbaz et al (2018) on France, reported positive ecological contributions of financial development. On the contrary, there are a considerable number of studies which reported that in fact financial development negatively affects the environment by increasing carbon emission. For instance, Zhang (2011) on China, Shahbaz et al. (2013c) on Indonesia, Javid and Sharif (2016) on Pakistan and Salahuddin et al. (2018) on Kuwait reported that the financial development has negative ecological consequences. Interestingly, there are also a considerable number of studies which reported that in fact there is no significant relationship between financial development and environmental degradation. For instance, Ozturk and Acaravci (2013) on Turkey, Omri et al. (2015) on MENA countries, Bekhet et al. (2017) on GCC countries, Charfeddine and Khediri (2016) on UAE and, Çoban and Topcu (2013) on EU countries reported neutral and mixed results. This implies that it will not be cogent to generalise the findings to existing evidence to the subject economies of ASEAN which have also been going through rapid economic and financial development. Keeping that in context, we are analysing the implication of this economic and financial development and its ecological consequences for ASEAN.

2.3 FDI and Environment Nexus

The third crucial nexus the subject study is exploring is the nexus between FDI and Environment. In the context of the recent development in the ASEAN region and remarkable increase in the Flows of FDI which are also expected to further increase in the years ahead (ASEAN Investment Report, 2018), it is important to account for the ecological consequences of such huge inflows of FDI for the region. As acknowledged in the beginning of this treatise, theoretically, the FDI can have positive to negative ecological consequences, depending on which transmission channel is more dominant. Putting it simply, whether, the pollution-haven hypothesis, the pollution-halo hypothesis, and/or the scale effects hypothesis prevails (Pao and Tsai, 2011). The empirical evidence suggests that in different countries and regions, FDI has shown to have different effects on environmental degradation. For instance, Pao and Tsai (2011) on BRICS, Al-mulali and Tang

(2013) on the GCC countries, Paziienza (2015a and 2015b) on OECD countries, Zhang and Zhou (2016) on the Chinese regions, Liu et al. (2017) and Jiang et al. (2017) on Chinese cities reported that the FDI improves environmental quality. On the contrary, He (2006) and Ren et al. (2014) on China, Hitam and Borhan (2012) and Lau et al. (2014) on Malaysia, Tang and Tan (2015) on Vietnam, paramati et al (2016) on 20 developing countries⁵, Sbia et al (2014) on Middle Eastern countries, Abdouli and Hammami (2017) on MENA, Shahbaz et al. (2015) on high, middle and low-income countries and Solarin et al. (2017) on Ghana and most recently, Shahbaz et al (2018) focusing on France reported that the FDI leads to an increase in environmental degradation. In fact, there are a number of studies which reported insignificant impact, for instance, Kiviyiro and Arminen (2014) on selected sub-Saharan countries and Lee (2013) on the G-20 countries. In fact, those studies which focused on some of the countries in the ASEAN region also reported mixed and contrasting results (contrast, Chandran and Tang (2013), Zhu et al (2016), Baek (2016). Nonetheless, they also ignored the important aspect of financial development and economic growth which are required to be seen in conjunction with the FDI. Concomitantly, keeping the financial and economic development in the ASEAN region as well as a remarkable influx of FDI, the subject study is intended to investigate the ecological consequences of these developments. In so doing, we are employing a set of empirical approaches and in the next section we elaborate on them.

3.1 Methodology

Firstly, we attempt to evaluate the cross-sectional dependence among variables by following Pesaran (2004, 2007). To start with the equation as follows:

$$\Delta Y_{it} = \pi_i Y_{i,t-1} + \gamma_i Z_{it} + \sum_{j=1}^{p-1} \theta_{ij} Y_{i,t-j} + \varepsilon_{it} \quad (\text{Eq. 1})$$

In which, Z_{it} is a deterministic component and $\sum_{j=1}^{p-1} \theta_{ij} Y_{i,t-j}$ is considered as ADF test. Therefore, ε_{it} is cross-sectional for objects i when they share the common factors. By defining that, we have:

$$\varepsilon_{it} = \theta_i f_t + u_{it} \quad (\text{Eq. 2})$$

θ_i means that each individual has different impact and u_{it} considers as no cross-sectional and no autocorrelation.

⁵ Brazil, China, Chile, Czech Republic, Colombia, Egypt, Greece, Hungary, Indonesia, India, Korea, Mexico, Malaysia, Peru, Poland, Philippines, Russia, South Africa, Turkey and Thailand.

By embedding the Equation 2 into Equation 1, we have:

$$\Delta Y_{it} = \pi_i Y_{i,t-1} + \gamma_i Z_{it} + \sum_{j=1}^{p-1} \theta_{ij} Y_{i,t-j} + \theta_i f_t + u_{it} \quad (\text{Eq. 3})$$

Thereafter, we follow the Pesaran (2004) to test whether there is an existence of cross-sectional dependence among variables or not which is built the hypothesis: $H_0: \theta_i \neq 0$ and $H_A: \theta_i = 0$.

Secondly, we elaborate on the test of stationarity based on Levin-Lin-Chu (2002), Im-Pesaran-Shin (2003) and Pesaran (2007). The general equation built by Levin-Lin-Chu (2002) test can be specified as follows:

$$\Delta Y_{it} = \pi_i Y_{i,t-1} + \gamma_i Z_{it} + u_{it} \quad (\text{Eq. 4})$$

In which, u_{it} is white noise, then $u_{it} \sim N(0; \sigma^2)$. Then, the hypothesis for the equation 4 having a unit root test against that Y_t is stationary. So, $H_0: \pi_i \neq 0$ and $H_A: \pi_i < 0$. The test of Levin-Lin-Chu (2002) had been used to estimate the Augmented Dickey-Fuller regression on the pooled panel data by Ordinary Least Squares. However, the Im-Pesaran-Shin (2003) develops the latter assumption, which corrects the drawbacks from the OLS approach by using varying autoregressive procedures across estimated individuals. Therefore, the results are known as group-mean of individual t-statistics with the following equation where $i = 1, 2, \dots, N$ and $t = 1, 2, \dots, T$ from the previous equation 4.

$$\bar{t}_{it} = i^{-1} \sum_{i=1}^N t_{iT}(\pi_i, \theta_{1i}, \dots, \theta_{ip_i}) \quad (\text{Eq. 5})$$

Thereafter, we extract the terms of $(\pi_i, \theta_{1i}, \dots, \theta_{ip_i})$ denotes the t-statistics for testing the unit root for the i^{th} individual procedures (in which π_i – lagged order, normally used to select optimal lag order). Therefore, \bar{t}_{it} , which represents Im-Pesaran-Shin (2003) test, is able to test the null hypothesis $H_0: \pi_i \neq 0 \forall i$ against $H_A: \exists i \in \{1, \dots, N\}, \pi_i < 0$. Subsequently, for the existence of cross-sectional dependency, the CIPS (Cross-sectional IPS) is developed on the basis of Im-Pesaran-Shin (2003). When IPS employs ADF, CIPS it uses cross-sectional ADF (called by CADF). The main concept of CIPS is to add the lagged cross-sectional value of mean of the individual \bar{Y}_t to control the effects of the common factors. Hence, CIPS is quite popular to use for

the existence of cross-sectional dependence. The other process of CIPS is similar to IPS except the existence of means of \bar{Y}_t as the specific factors for cross-sectional dependency.

Thirdly, we will discuss the methodologies used for testing whether the co-integration in panel data exists or not. The approach from co-integration test for panel data is mainly based on the following notion:

$$y_{it} = x'_{it}\beta_i + z'_{it}\gamma_i + e_{it} \quad (\text{Eq. 6})$$

The test is focused on the covariates in x_{it} are not co-integrated themselves. β_i denotes the vector conveying the co-integrating phenomenon, which might differ across panels. γ_i is a vector with coefficients on Z_{it} , which is known as deterministic terms to control panel-specific effects and linear time trends. e_{it} is error term, which should be in accordance with white noise $e_{it} \sim N(0; \sigma^2)$.

Kao (1999) indicates the assumptions of co-integrating vector from Equation 6 with $\beta_i = \beta$; therefore, the panels follow common slope coefficients. Thus, Kao (1999) proposes five kinds of test such as Modified Dickey-Fuller t, Dickey-Fuller t, Augmented Dickey-Fuller t, Unadjusted modified Dickey-Fuller t and Unadjusted Dickey-Fuller t from the Dickey-Fuller regression:

$$\hat{e}_{it} = \rho\hat{e}_{i,t-1} + v_{it} \quad (\text{Eq. 7})$$

In which, ρ is the common Auto Regression parameter of the estimated residuals. Meanwhile, the Augmented Dickey-Fuller regression is given by

$$\hat{e}_{it} = \rho\hat{e}_{i,t-1} + \sum_{j=1}^p \rho_j \Delta\hat{e}_{i,t-j} + v_{it} \quad (\text{Eq. 8})$$

Interestingly, in this approach, ρ reflects the number of lagged difference terms. Noticeably, the asymptotic distribution for all Kao (1999) tests must be converged into $N(0,1)$. *In contrast*, Pedroni (1999) evaluates each panel-specific co-integrating vector from Equation 6 has different individual slope coefficients. Then, the Pedroni (1999) test employs the unit root test of estimated residuals by Augmented Dickey-Fuller regression. However, the interesting thing is to allow each ρ_i instead of the same ρ (like Kao (1999)). In addition, this approach is considered to be following the convergence characteristics after appropriate standardization. Another co-integration test is employed by Westerlund (2005), which assumes that the specific co-integrating vectors have different individual slope coefficients. This test allows to perform well under the cross-sectional dependency and it is usually used as a robustness test. Additionally, Westerlund

(2005) is normally used to deal with the problem raising by determining structural breaks endogenously.

Finally, many previous studies proposed that the presence of co-integration should be referred to the two main methods such as OLS-based estimators—FMOLS (Fully Modified OLS) and DOLS (Dynamics OLS). The main difference between the two approaches is how to correct the autocorrelation in regression. FMOLS allows using Newey-West for correction whereas DOLS accepts to add more lagged and lead variables. Pedroni (1996, 2001) suggested the approach to estimate the coefficients, which is used to measure the long-run effects.

$$\hat{\beta}_{\text{FMOLS}} = \left(\sum_{i=1}^N \hat{L}_{22i}^{-1} \sum_{t=1}^T (x_{it} - \bar{x}_i)^2 \right)^{-1} \sum_{i=1}^N \hat{L}_{11i}^{-1} \hat{L}_{22i}^{-1} \left(\sum_{t=1}^T (x_{it} - \bar{x}_i) y_{it}^* - T \hat{\delta}_i \right) \quad (\text{Eq. 9})$$

In which,

$$y_{it}^* = (y_{it} - \bar{y}_i) - \left(\frac{\hat{L}_{21i}}{\hat{L}_{22i}} \right) \Delta x_{it} + \left(\frac{\hat{L}_{21i} - \hat{L}_{22i}}{\hat{L}_{22i}} \right) \beta (x_{it} - \bar{x}_i) \quad (\text{Eq. 10})$$

and we denotes $\hat{\delta}_i$ as

$$\hat{\delta}_i \equiv \hat{\Gamma}_{21i} + \hat{\Omega}_{21i}^0 - \left(\frac{\hat{L}_{21i}}{\hat{L}_{22i}} \right) (\hat{\Gamma}_{22i} + \hat{\Omega}_{22i}^0) \quad (\text{Eq. 11})$$

In order to clarify, we refer to Ω as asymptotic covariance matrix for long-run variance and Γ as dynamic covariance. In addition, L is a lower triangular matrix with partition calculation. Then, DOLS estimator is employed which takes the following form:

$$y_{it} = \beta_i' x_{it} + \sum_{j=-q}^q \zeta_{ij} \Delta x_{i,t+j} + \gamma_{li}' D_{li} + \varepsilon_{it} \quad (\text{Eq. 12})$$

In which, q is known as the numbers of leads/lags chosen for the models. Thereafter, DOLS estimator is referred to Kao and Chiang (2001) for using the finite sample properties.

3.2. Data

In this study, we choose five ASEAN countries which are also the largest economies of the ASEAN block. These include Singapore, Thailand, Malaysia, Philippines and Indonesia over the period from 1982 to 2014. The main reason to focus on these economies and the time period of 33 years is data availability from the World Bank and well-balanced data for cross-sectional with time-series data characteristics. There are seven variables used in this study and the description as well as sources of data are represented in Table 1 below.

Table 1 Data description

Variables	Explanation	Measurement	Source
CO ₂	CO ₂ emissions (metric tons per capita)	The amount of carbon dioxide emissions was calculated under the procedure of stemming from burning fossil fuel including solid, liquid, and gas fuels and gas flaring.	World Development Indicators
FDI	Foreign direct investment, net inflows (percentage of Gross Domestic Product)	There were net inflows computing by new investment inflows excluding disinvestment. This figure was divided by the total Gross Domestic Product	World Development Indicators
GDP	The annual percentage growth rate of GDP at market prices based on constant local currency.	GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. Then we calculate the growth rate from the previous year.	World Development Indicators

Financial development and Structure Dataset are measured by a group of variables here

BCBD	Bank credit to Bank Deposit (Percentage)	Private credit was retrieved by deposit money banks report; specifically, IFS line 22d, FOSAOP over the bank deposits was extracted from IFS lines 24, FOST, and 25, FOSED.	Čihák et al. (2012) The World Bank ⁶ International Monetary Fund ⁷
Listco_pc	The number of listed companies per 10.000 population	Total number of listed companies was scaled by 10.000 population	World Development Indicators
Int. Debt	International debt issued over total Gross Domestic Product	The amount of outstanding of International Debt Securities was divided by total Gross Domestic Product	Bank for International Settlements World Development Indicators

(Source: The author's collection)

⁶ World Bank in Washington District of Columbia

⁷ International Monetary Fund in Washington District of Columbia

For financial development, we took an inclusive approach. We chose three categories such as bank credit to bank deposit, the number of listed companies and international debt representing financial development and structure dataset. These are the components for the banking system, equity market and debt market, which reflect the ability for financial integration and development by each country. After data collection, we transformed the absolute value to the percentage change for each country. These five economies are supposed to advance and emerging economies, which is attracting scholars' attention.



Figure 1. CO2 emission in the ASEAN region by World Bank Data Sources

(Source: World Development Indicators)

The figure 1 summarises the CO2 emission in the ASEAN region by World Bank Data Sources. In which, Malaysia is the country which lies into the group from 6.5 to 10.31 metric ton carbon dioxide in the ASEAN area. The remaining ones are categorized into one group with 2.77 – 6.50 metric ton.

3.3. Descriptive Statistics

In order to gain some insight into the characteristics of the dataset, we performed the descriptive statistics analysis as presented in Table 2.

Table 2. Descriptive statistics

Variable	Mean	Std. Dev.	Skewness	Kurtosis	J-B
CO2	0.034753	0.125603	1.020753	10.67684	433.8***

FDI	-0.12543	4.769969	-8.031189	91.36219	55000***
GDP	-0.29684	2.852479	-4.577124	45.89052	13000***
BCBD	-0.00248	0.086582	-0.7608297	8.23216	204.1***
Listco_pc	0.071519	0.348047	8.136386	84.77175	48000***
Int. Debt	0.127683	0.417534	2.527964	10.59441	572.3***

*This table reports the summary statistics including mean, standard deviation (Std. Dev.), skewness, excess kurtosis, and Jarque-Bera (J-B) test. The symbols * , ** , and *** denote the significance at the 10%, 5%, and 1% levels, respectively.*

Based on the descriptive statistics, the value of skewness for all variables is positive and excess from zero. Hence, all variables are demonstrated the characteristics for skewness to the right. In addition, the excess kurtosis is greater than zero, implying that all variables' distributions experience the fat-tailed phenomenon. From the skewness and kurtosis findings, all variables are rejected to be normally distributed. The Jarque-Bera test subsequently confirmed the results. These findings support the notion to employ the set of quantitative techniques as manifested in the next section.

4.1 Empirical Findings

4.2. Panel Unit Root Test

Before the application of panel unit tests for stationarity of the variables, we tested whether a cross-sectional dependency exists or not. In so doing, we employ the Breusch-Pagan LM (1980), Pesaran (2004) and Frees (1995, 2004) tests and the results are in the following Table 3.

Table 3. Cross-section dependence tests

Test	parameter	Results
Breusch-Pagan LM	14.623	Fail to reject null hypothesis
Pesaran	1.724*	Reject at significance level 10%
Frees' test	0.080	Fail to reject null hypothesis

*The null hypothesis is that H_0 : there is no cross-sectional dependence. Levels of significance: * p -value < 0.1, ** p -value < 0.05, *** p -value < 0.01.*

The results indicate the strength and existence of cross-sectional dependency. The null hypothesis proposed by these tests is no presence of cross-sectional dependency. It showed that

only the Pesaran (2004) approach rejects this null hypothesis at a significance level 10% whereas Breusch-Pagan LM (1980) fails to reject. Then, using Frees' Q-distribution (T-asymptotically distributed) based on the approach proposed by Frees (1995, 2004) also failed to reject the null hypothesis. Meanwhile, the Pesaran test is mainly based on standard normal distribution. With the analysis above, we evaluate that there is no cross-sectional dependence. Nevertheless, in order to be strongly convinced, we employ both the first and second-generation test for panel unit root tests, which might provide inferences that are more reliable. Basically, we employ multiple panel unit root tests to check whether our variables are stationary or not. These include Levin-Lin-Chu (2002), Im-Pesaran-Shin (2003) and Pesaran panel unit root test in the presence of cross-section dependence by Pesaran (2007). These approaches are abbreviated by LLC, IPS and CIPS, respectively. Although we pass through the cross-sectional dependency, we choose to consider for both cases.

Table 4. Unit root tests

Variable	Test	Intercept	Intercept and Trend	Conclusion
CO ₂	LLC	-4.9030***	-3.9189***	Stationary at significance level 1%
	IPS	-6.5278***	-6.8139***	
	CIPS	-4.942***	-5.168***	
FDI	LLC	-4.6187***	-4.0224***	Stationary at significance level 1%
	IPS	-6.8589***	-7.2387***	
	CIPS	-4.911***	-5.158***	
GDP	LLC	-7.4287***	-6.3610***	Stationary at significance level 1%
	IPS	-7.0490***	-7.2209***	
	CIPS	-5.752***	-5.804***	
BCBD	LLC	-5.1850***	-4.4493***	Stationary at significance level 1%
	IPS	-2.6765***	-2.9133***	
	CIPS	-2.715***	-2.896**	
Listco_pc	LLC	-3.9101***	-3.5697***	Stationary at significance level 1%
	IPS	-4.7903***	-5.2802***	
	CIPS	-3.881***	-3.915***	
Int. Debt	LLC	-3.8427***	-2.6557***	Stationary at significance level 1%
	IPS	-6.4860***	-6.3764***	
	CIPS	-5.148***	-5.057***	

The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively. A Levin-Lin-Chu unit-root test, H_0 : Panels contain unit roots and H_A : Panels are stationary. As regards Im-Pesaran-Shin unit-root test, H_0 : All panels contain unit roots (or all the series are non-stationary) and H_A : Some panels are stationary. Regarding Pesaran Panel Unit Root Test with cross-sectional, H_0 : homogeneous non-stationary ($b_i = 0$ for all i); and H_A : stationary.

With the strict assumption and a broad set of tests from LLC, IPS and CIPS, all variables are stationary at significance level 1%. Whether the presence of cross-sectional dependency exists or not, the findings in Table 4 assure that all panels have stationarity.

4.3 Co-integration Analysis

In order to provide the co-integration analysis, we employ the Pedroni (1999, 2004) test to answer whether there is the existence of panel co-integration among our variables. The null hypothesis postulates that there is no co-integration in all tests.

Table 5. Panel co-integration tests by Pedroni (1999, 2004)

Test-Statistics	Intercept	Intercept and Trend
Modified Phillips-Perron	-0.2944	0.4553
Phillips-Perron	-7.4660***	-7.5192***
Augmented Dickey-Fuller	-7.6316***	-7.3770***

*The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively. Null hypothesis is no co-integration between variables.*

In Table 5 above, the majority of tests indicate rejection of the null hypothesis. This implies the presence of co-integration for both cases i.e. intercept as well as intercept and trend in the panel. We employ Kao (1999) test of no co-integration between a group of variables such as Co2, FDI, GDP, BCBD, Listco_pc and Int. Debt.

Table 6. Panel co-integration tests by Kao (1999)

Test-Statistics	Intercept	Subtract cross-sectional means
Modified Dickey-Fuller	-19.0069***	-15.7540***
Dickey-Fuller	-11.2485***	-11.1549***
Augmented Dickey-Fuller	-9.3509***	-9.4790***
Unadjusted modified Dickey-Fuller	-20.1251***	-20.4243***
Unadjusted Dickey-Fuller	-11.2720***	-11.4651***

*The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively. H_0 : No co-integration and H_A : All panels are co-integrated*

It is clearly seen that all tests following the Kao (1999) approach unanimously reject the null hypothesis of no cointegration. Therefore, we can conclude that there is co-integration phenomenon in our research variables. This finding is of high significance and provides strong evidence that the variables have a long run relationship.

A point to acknowledge at this juncture is that study by Hossfeld (2010, p.16) indicates that it is necessary to test robustness if the different test by Pedroni (1999, 2004) generates different test statistics for the same test decision. The rationale of doing so comes from Monte Carlo

simulations, which show various test-statistics relying on panel dimension and the assumed data generating process. It is very important to provide additional co-integration testing which proves the robustness for structural breaks and cross-sectional dependence. One of the reliable tests is Westerlund (2005) with the null hypothesis being no co-integration for all panels.

Table 7. Westerlund Panel co-integration tests

Test statistics	Value
Gt	-3.928***
Ga	-14.139
Pt	-9.097***
Pa	-16.509**

The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively. The Ga and Gt test statistics are to test $H_0: a_i = 0$ for all i whereas the $H_A: a_i < 0$ for at least one i . In addition, the P_a and P_t test statistics implying pool information over all the cross-sectional units with $H_0: a_i = 0$ for all i whereas the $H_A: a_i < 0$ for at least one i .

The results of Westerlund's tests presented in Table 7 suggest that based on the critical values generating from bootstrapped robust, there are three out of four tests which reject the null hypothesis. These findings further confirm that there is a long-run relationship among variables based on cointegration.

4.4 Estimation

We choose two methodologies such as FMOLS (Fully Modified OLS) and Pooled-Mean Group (PMG) for estimating the long-run relationships for our variables. We choose FMOLS as our main approach because FMOLS employs the Newey-West to correct the autocorrelation of the error term U_{it} . However, if we choose lagged variables and lead variables in our models to control the errors of autocorrelation on the error term U_{it} , we have the choice of Dynamic OLS.

Table 8. Estimation of co-integrating relationship by FMOLS (trend and non-trend)

Estimation method: Long-run coefficient	Fully Modified OLS	
	Trend	No-trend
FDI	-0.01 [-2.26]	-0.01 [2.30]
GDP	0.01** [2.25]	0.01** [2.20]
BCBD	0.26*** [6.25]	0.26*** [6.23]
Listco_pc	0.17*** [2.97]	0.18*** [2.77]
Int. Debt	-0.01 [-1.48]	-0.01 [-1.96]

The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively whereas t-statistics of the corresponding coefficients are reflected in square brackets.

For both cases of trend and no-trend, there are three significant variables such as GDP, Bank credit (BCBD) and listed companies as a percentage of the population (listco_pc) which positively influence (at 5% and 1% significance level) the CO₂ emissions in five ASEAN economies. Hence, more financial development implies more carbon dioxide emissions. The credit creation in specific shows that a 1% change in bank credit over bank deposit, on average, results in a 0.26% change in the level of carbon dioxide emission for our chosen economies in ASEAN. Moreover, it is also interpreted in the light of results that a 1% increase in the number of listed leads to the 0.17% and 0.18% increase in CO₂ emission with and without trend approaches, respectively. Additionally, the results apparently indicate the existence of the long-term co-integration relationship between CO₂ emissions and economic growth (GDP) that is also statistically significant. When the GDP rises 1%, which only contributes to a 0.01% increase in CO₂ emission. Noticeably, the GDP growth causes the level of CO₂ emission less than the financial development does, which prima facie evident in the magnitude of coefficients.

Table 9. Estimation of co-integrating relationship by DOLS

Estimation method:	
Long-run coefficient by Dynamic OLS	
FDI	0.03** [2.03]
GDP	-0.01 [0.83]
BCBD	0.17 [-1.03]
List co_pc	-0.002*** [3.02]
Int. Debt	-0.04 [0.19]

The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively whereas t-statistics of the corresponding coefficients are reflected in square brackets.

The application of Dynamic OLS yielded results which were different from those obtained by the Fully Modified OLS. The 'FDI' is turned out to be a major factor causing CO₂ emission at significance level 5%. Specifically, it showed that a 1% increase in FDI will cause 0.03% increase in CO₂ emission. This finding is quite reasonable because foreign direct investment

is expected to contribute to the level of carbon dioxide by building many plants as well as factories in the ASEAN region. Another considerable estimation is the number of listed companies, it showed negative impact implying that financial development through equity market proves to be more environmentally friendly as it decreases CO₂ emission. Specifically, if the number of listed companies increases by 1%, the CO₂ emission will decrease by 0.002% at 1% level of significance. This finding is in contrast to the previous estimation by Fully Modified OLS. The main reason for this difference is a method to solve autocorrelation by using lagged and lead variables. The parameters generated by OLS differ from the ones of FMOLS estimator because the requirements of DOLS is no initial estimation and non-parametric correction. Therefore, Kao and Chiang (2001) indicate that DOLS outperforms FMOLS approach. Not only is DOLS computationally simpler but it also avoids biased errors better than FMOLS. Hence, by employing this methodology, we can investigate the existence of a relationship between FDI and CO₂ emission.

4.5 Estimation of Environmental Kuznets curve

In order to analyse the long run impact of economic growth on environmental degradation, we add the quadratic of GDP i.e. GDP². Table 10 here shows the relationship by two different methodologies in long-run estimation including FMOLS and DOLS.

Table 10: Environmental Kuznets Curve, FMOLS & DOLS Estimation

Estimation method: Long-run coefficient	Estimation	
	FMOLS	DOLS
FDI	-0.01 [-2.42]	0.04 [0.52]
GDP ²	-0.0009 [-5.51]	-0.0009 [0.48]
GDP	0.01*** [2.95]	0.02** [1.86]
BCBD	0.19*** [4.60]	0.09 [-0.87]
Listco_pc	0.19*** [3.09]	-0.22*** [4.01]
Int. Debt	-0.01 [-1.58]	-0.13** [1.72]

*The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively whereas t-statistics of the corresponding coefficients are reflected in square brackets.*

The rest of the results are similar to the previous findings in the model without quadratic of GDP. It showed that one per cent increase in GDP will trigger 0.01% (at 1% significance level)

and 0.02% (at 5% significance level) in CO₂ emission by Fully Modified OLS and Dynamic OLS respectively. In the FMOLS model, the ratio of bank credit and bank deposit have a positive relationship with CO₂ emission at 1% significance level. Similarly, the number of listed companies are contrasted in two different methodologies. This shows a positive coefficient in FMOLS whereas the coefficient in DOLS is negative. Both cases are significant at 1%. More interestingly, the international debt is a new finding in this model. This factor generates the negative coefficient in DOLS at significance level of 5%. This means that one per cent increase in international debt will decrease by 0.13% in the level of carbon dioxide emission in significance level of 5%. Most importantly, the coefficients of GDP² is showed a negative sign indicating the presence of the Environmental Kuznets curve, however, the results were not statistically significant. This implied that the continued economic growth in the ASEAN in its own steam shall be expected to harbour environmental improvements.

4.6. Robustness Test (white noise test for residuals)

Considering that fact that there are some contrasting results (signs of 'Listco_pc') in different models, we decided to test the validity and robustness of our model. Thus, we extract the residuals in all the long-term relationships and test for white noise to ensure that our model is not spurious.

Table 11. White noise test for residuals

Models	White noise test statistics	Results
CO ₂ emission (fdi, gdp, bcbd, listco_pc, intldebt) by FMOLS	48.6358	Fail to reject Residual is white noise
CO ₂ emission (fdi, gdp, bcbd, listco_pc, intldebt) by DOLS	22.9067	Fail to reject Residual is white noise
CO ₂ emission (fdi, gdp ² , gdp, bcbd, listco_pc, intldebt) by FMOLS	27.6095	Fail to reject Residual is white noise
CO ₂ emission (fdi, gdp ² , gdp, bcbd, listco_pc, intldebt) by DOLS	48.2601	Fail to reject Residual is white noise

*Null hypothesis for time series $\{x_t\}$ or set of residual $\{r_t\}$ is iid $(0, \sigma^2)$ or White noise $(0, \sigma^2)$. The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels*

Based on the results of the white noise test for each model, we can hereby confirm that all of the residuals are white noise with iid $(0, \sigma^2)$. Therefore, our regression results are unbiased and consistent and the model is not spurious. The empirical results lead us to conclude.

5. Conclusion & Policy Implications

In the last few decades in general, and particularly since the Global Financial Crisis, the emerging economies from Asia have acted as a locomotive of global growth. In this context, the ASEAN region has emerged as a crucial player with rapid economic and financial growth as well as attracting an unprecedented inflow of foreign direct investment. While these economic and financial developments are appreciable in the monetary sense, it is cogent to look at the ecological consequence of these factors for the emerging ASEAN. Contextualising on these backgrounds and motivating factors in this study we analysed the ecological implication of the economic growth, financial development and FDI for the ASEAN economies. In this endeavour, we drew on the historical dataset from 1982 to 2014 and employed a broad set of quantitative techniques for panel analysis which entailed Dynamic Ordinary Least Squares (DOLS) and Fully Modified OLS (FMOLS) approaches. Our results perspicuously demonstrate the existence of a statistically significant long-term relationship between CO₂ emission and foreign direct investment, gross domestic product, financial development (bank credit over bank deposit and the number of listed companies in equity markets). The only aspect of financial development where we could not find significant ecological implication was international debt which did not show a strong relationship with carbon dioxide emission. This was intuitive and cogent and implied that the domestic credit creation is rather more influential on the environmental degradation in the long run.

Our empirical results also lead us to conclude that the economic growth and increase in the FDI leads to an increase in the environmental degradation in the ASEAN economies. Hence, the rapid economic growth and foreign direct investment which has been observed in the last few decades and expected to continue will have negative ecological consequences. There is significant evidence of Pollution Heaven Hypothesis (PHH). There is also evidence of Environmental Kuznets Curve (EKC) in the ASEAN economies as the quadratic term for GDO was found to have a negative impact. However, the results were not statistically significant implying that the continuous growth under its own steam shall not harbour environmental sustainability. This also has crucial policy implications and manifestations of active policy responses for more inclusive

and sustainable growth. In terms of financial development in ASEAN economies, the evidence on hand indicates that the increase in credit creation by the banking sector (bank credit over bank deposit) adversely affects the environment. This is intuitive as the banking credit system is mainly used to foster the lending channel for industries, which are not 'green' but are engaged in intensive 'energy consumption'. The financial development in terms of capital market development brought us interesting and contrasting results. We found contrasting results for the capital market expansion (the number of listed companies) on CO₂ emission. Especially, the estimates by FMOLS indicates a positive impact, yet the estimates provided by the DOLS indicated a negative impact on environmental degradation. At this juncture, given the fact that the estimates by the DOLS are more robust against bias we conclude that this measure of financial development i.e. the number of listed companies will decrease the level of CO₂ emissions. In a nutshell, we conclude that rapid economic growth and FDI can have unintended ecological consequences for the ASEAN economies. In the policy context, it is vital to focus on the more sustainable economic growth by allocating resources to environmental friendly sectors of the economy. The presence of a weak evidence on EKC reflects the importance of active policy responses. It is also advisable to direct the flows of FDI into more sustainable and greener sectors of the economy. In terms of financial development, it is also vital to allocate the financial resources to the environmental friendly sectors of the economy and hence, green finance is the way forward for the emerging ASEAN.

In this study we focused on the CO₂ emissions due to their ecological and environmental significance, however, for further research we propose that the framework of the subject study can be extended by inclusion of the Ecological footprints in analysis. Further research may also include the regulatory aspect and role of innovations and R & D in the renewable sectors of the ASEAN region to overcome the adverse and unintended consequences of the subject factors.

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