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**Article**

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# Globalization, Financial Development, and Environmental Degradation in the Presence of Environmental Kuznets Curve: Evidence from ASEAN-5 Countries

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**ABSTRACT**

ASEAN is regarded as an economically dynamic region with notable policies towards economic openness, implying the encouragement of globalization and trade liberalization. Considerable globalization and financial development processes, together with the incremental energy demand, necessitated the issue of controlling environmental damage. The main objective of this research is to evaluate the impacts of globalization and financial development, incorporating energy consumption, urbanization and GDP per capita, on carbon dioxide emissions with the presence of Environmental Kuznets Curve (EKC) model for selected ASEAN countries. From the author's best knowledge and review of literature, there has been no study that only focuses on ASEAN region, and this paper serves as the first one in the discipline. This research approaches the heterogeneity in the panel data over the 1971-2014 period by utilizing the fixed and random effects regression models. The author uses the tests based on Durbin–Hausman–Wu statistic to determine the appropriate models. The findings indicate that (i) financial development, energy consumption and urbanization boost the carbon dioxide emissions; (ii) globalization as an aggregate measure significantly increases carbon dioxide emissions and the effect mainly comes from the economic globalization facet; (iii) the EKC hypothesis is underpinned in ASEAN-5 countries. Hence, this suggests crucial implications for policy-makers.

**Keywords:** Globalization, Financial development, Carbon dioxide emission

**JEL Classifications:** F64, O44, Q56

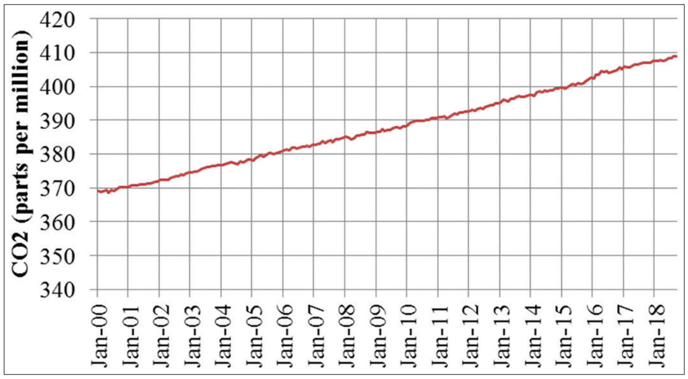
## 1. INTRODUCTION

In recent years, the challenging concern of worsening global environmental quality has strongly manifested, which is clearly illustrated by the upward trend of CO2 (Carbon Dioxide - one of the main components of the greenhouse effect) in the atmosphere (as displayed in Figure 1).

Albeit economists as well as policy-makers endeavored to explore and scrutinize the determinants of CO2 emissions such as energy consumption, economic growth, financial development and urbanization by various national and international researches in order to support sustainable development policies, the results regarding the relationship between the aforementioned factors and environmental damage remain controversial (Omri, 2013; Stern, 2004; Dinda, 2004; Omri et al. 2015; Shahbaz et al., 2015b; Shahbaz et al., 2016b; Dar and Asif, 2017; Phong et al., 2018).

As an economically open and dynamic region, ASEAN experiences rapid globalization process, especially economic globalization through trade and investment activities. The role of finance, namely the importance of credit in private sector, enhances economic activities of ASEAN countries. Lately, ASEAN has been recognized as one of the top regions in the world by economic growth, which increases the incomes of member countries, fosters the living standards of their residents, and facilitates urbanization.

**Figure 1:** Atmospheric CO2 levels




Source: Author's calculations. Data is collected from https://climate.nasa.gov/vital-signs/carbon-dioxide.

The intense globalization and financial development progresses, along with the upsurge in energy demand for economic activities, induce substantially higher CO2 emissions. Thus, the scrutiny of environmental quality with the presence of financial development, globalization, and urbanization necessitates special attentions.

Moreover, it is essential that variable omission is avoided so as to gain accurate findings when investigating the existence of EKC hypothesis (Pata, 2018). The major goal of this paper is to scrutinize the effects of globalization, financial development, energy consumption, urbanization and GDP per capita on carbon dioxide emissions under a multivariate framework with the inclusion of Environmental Kuznets Curve (EKC) model for selected ASEAN countries. To the best of the author's knowledge, this is the first research to examine the dynamic connections between energy consumption, GDP per capita, urbanization, and carbon dioxide emissions when incorporating globalization and financial development in case of ASEAN countries, with the presence of EKC hypothesis. The rest of this article consists of 5 parts and is organized in the following order: The "Literature Review" part stresses the EKC hypothesis as well as relevant researches that form the basis for subsequent analyses; "Materials and Methods" illuminates the variables, estimation model and econometric methodology utilized in this study; "Results" gives explanation to the findings; "Discussion" provides arguments and further information; and finally, the "Conclusions" part contains important summary of this paper with the inclusion of policy implications drawn from the empirical results.

## 2. LITERATURE REVIEW

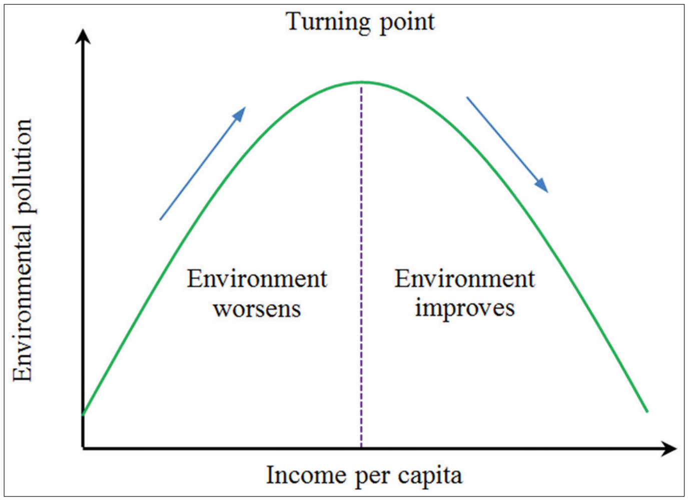
The last several decades witnessed the strong development of economic activities which raised concerns for their impacts on the environment at both national and international levels. The link between economic growth and environmental quality has drawn considerable attentions since Grossman and Krueger (1991) proposed the Environmental Kuznets Curve (EKC) hypothesis which assumes that economic growth positively influences CO2 emissions in the beginning stage, but the effect is negative in the subsequent stage after the CO2 emissions reaches the maximum level connected with a certain amount of income per capita. Such movement of CO2 emissions is described by the inverted U-shaped Environmental Kuznets Curve indicated in Figure 2.

Following Grossman and Krueger (1991), many a research focused on testing the Environmental Kuznets Curve (EKC) hypothesis in different countries, and the results varied. The EKC hypothesis is underpinned by notable studies for a large number of countries including Lindmark (2002) for Sweden; Ang (2007) for France; Jalil and Mahmud (2009) for China; Ghosh (2010), Jayanthakumaran et al. (2012) for India and China; Nasir and Rehman (2011), Ahmed and Long (2012), Javid and Sharif (2016) for Pakistan; Saboori et al. (2012) for Malaysia; Alam et al. (2012) for Bangladesh; Baek and Kim (2013) for South Korea; Shahbaz et al. (2014) for Tunisia; Ahmed (2014) for Mongolia; Baek (2015) for Iceland; Shahbaz et al. (2015a) for Portugal; Tang and Tan (2015) for Vietnam; Zambrano-Monserrate et al. (2016) for Ecuador; Balaguer and Cantavella (2016) for Spain; Al-Mulali et al. (2016) for Kenya; Bento and Moutinho (2016) for Italy; Ahmad et al. (2017) for Croatia; Ozturk and Acaravci (2013), Yavuz (2014), Gokmenoglu and Taspinar (2016), Ozatac et al. (2017), Pata (2018) for Turkey; Cole et al. (1997) for 7 countries; Halkos (2003) for OECD and non-OECD countries; Apergis and Payne (2009) for Central America; Cho et al.(2014) for OECD; Pao and Tsai (2011), Sinha and Sen (2016) for BRICS; Farhani et al. (2014) for 10 MENA countries; Kasman and Duman (2015) for European countries; Zaman et al. (2016) for 34 developed and developing countries; Zhang et al. (2017) for 10 Newly Industrialized countries (NICs-10).

On the contrary, the EKC hypothesis is not supported by Torras and Boyce (1998), Roca et al. (2001) for Spain; Day and Grafton (2003) for Canada; Chebbi (2009), Fodha and Zaghdoud (2010) for Tunisia; Pao et al. (2011) for Russia; Du et al. (2012) for China; Pal and Mitra (2017) India and China; Arouri et al. (2012) for 12 Middle East and North African countries; Giovanis (2013) for United Kingdom; Ozcan (2013) for 12 MENA countries; Wang et al. (2013) for 150 nations; Farhani and Ozturk (2015) for Tunisia; Lacheheb et al. (2015) for Algeria; Begum et al. (2015) for Malaysia; Mallick and Tandi (2015), Rehman and Rashid (2017) for SAARC countries; Bento and Moutinho (2016) for Italy; María and Jesús (2016) for 22 Latin American and Caribbean countries; Neve and Hamaide (2017) for 28 countries; Zoundi (2017) 25 African countries.

The rapid economic growth process requires more energy consumption, hence damaging the environment (Islam et al., 2013; Zhang and Cheng, 2009; Shahbaz et al., 2016a; Shahbaz et al., 2017a). Manifold studies tested the Environmental Kuznets Curve (EKC) hypothesis with the influence of energy consumption. For instance, Pao and Tsai (2010) examined the impacts of energy consumption, economic growth on CO2 emissions and concurrently verified the EKC hypothesis in BRIC countries in the 1971-2005 period; and the outcomes confirmed the existence of the EKC hypothesis and denoted that energy consumption and economic growth were main factors raising CO2 emissions. Jaunky (2011) analyzed 36 high-income countries from 1980 to 2005 and found that energy consumption boosted CO2 emissions; also, EKC was evidenced in Greece, Malta, Portugal, Oman, and

**Figure 2:** Environmental Kuznets curve




United Kingdom. Shahbaz et al. (2014) applied ARDL approach and VECM Granger causality tests and detected the occurrence of EKC in Tunisia in 1971-2010 period, together with the positive effects of energy consumption on CO2 emissions. Rehman and Rashid (2017) inspected the role of energy consumption on environmental damage under multivariate analysis in SAARC countries and indicated that energy consumption degraded the environment; also, the presence of EKC was affirmed.

Recently, besides energy consumption, a large number of researchers have tested the EKC hypothesis based on the link between economic growth and environmental quality with the inclusion of some important factors such as financial development, globalization and urbanization. Tamazian et al. (2009) scrutinized the connections between financial development, economic development and CO2 emissions in BRIC countries during 1992 and 2004 and proved the evidence of EKC as well as the negative cause of financial development on CO2 emissions. Shahbaz et al. (2013b) employed ARDL and ECM approach over the 1965–2008 period to witness the occurrence of EKC; in addition, they found that financial development and economic development respectively reduced and stimulated CO2 emissions. Ozturk and Acaravci (2013) reported no link between financial development and CO2 emissions in Turkey from 1960 to 2007, but the proof of EKC was detected. Shahbaz et al. (2013a) included energy intensity, economic growth and globalization in their study using annual data of Turkey from 1970 to 2010 and applied ARDL and VECM Granger causality approach; they observed the presence of EKC and noted that energy intensity and economic growth made CO2 emissions rise but globalization had opposite effect. Boutabba (2014) studied the long-run equilibrium between CO2 emissions, financial development, economic growth, energy consumption and trade openness for the case of India and found the evidence of the long-run and causal relationships between CO2 emissions, financial development, income, energy use and trade openness in which financial development and energy use increased CO2 emissions; also, EKC was discovered.

Shahbaz et al. (2015b) showed that globalization, energy consumption, financial development, and economic growth exacerbated the environmental quality of India from 1970 to 2012 and observed that EKC occurred in India. Farhani and Ozturk (2015) rejected the EKC hypothesis in Tunisia but concluded that all variables (real GDP, energy consumption, financial development, trade openness and urbanization) contributed to environmental pollution in the period 1971-2012. Al-Mulali et al. (2015) studied the connections of economic growth, urbanization, trade openness, financial development and renewable energy on pollution in 23 European countries during the period 1990-2013 and discovered the positive influence of GDP growth, urbanization and financial development on CO2 emissions, while trade openness has negative one. Shahbaz et al. (2016b) assessed the asymmetric impacts of financial development on environmental quality in Pakistan from the first quarter of 1985 to the last quarter of 2014 and concluded that ineffective use of energy aggravated the environmental quality; additionally, financial development based on banks worsened the environment. Javid and Sharif (2016) inspected the roles of financial development, energy consumption, economic growth in CO2 emissions in Pakistan employing ARDL method on 1972-2013 data and identified the EKC pattern as well as acknowledged that the higher levels of financial development, energy consumption and economic growth led to the greater CO2 emissions. Dogan and Turkekul (2016) found no sign of EKC in United States; moreover, they reported that trade activities promoted the environmental quality while energy consumption, urbanization damaged the environment and financial development had insignificant effect.

Dogan and Seker (2016) spotted the EKC trace in OECD countries associated with the positive causal relationship between energy consumption and CO2 emissions, whereas openness and financial development decreased CO2 emissions. Solarin et al. (2017) pointed out the detrimental effects of financial development, urbanization, energy consumption and economic growth on the environmental quality in Ghana during 1980 and 2012. Saidi and Mbarek (2017) conducted the study for emerging countries and found no evidence of the inverted U-shaped EKC; rather, they observed that financial development and urbanization enhance environmental quality while income facilitates CO2 emissions. Xing et al. (2017) utilized the STIRPAT model and ARDL approach for the case of China and indicated that financial development could contribute to the escalation in CO2 emissions. Dar and Asif (2017) realized no relationship between economic growth and environmental quality in India but witnessed the harmful impacts of financial sector development and energy consumption on greenhouse gas emissions. Salahuddin et al. (2017) demonstrated the positive response of CO2 emissions in Kuwait during the period 1980-2013 under the effects of economic growth, electricity consumption, foreign direct investment and financial development by using ARDL approach and VECM Granger causality analysis.

Recently, Shahbaz et al. (2017b) gauged the response of CO2 emissions to the changes of globalization level by incorporating energy consumption and economic growth in Japan from 1970 to 2014, which denoted that globalization, economic growth and energy consumption positively induced CO2 emissions. Twerefou et al. (2017) examined the EKC hypothesis in 36 Sub-Saharan

Africa and scrutinized the influences of economic growth and globalization on environmental quality from 1990 to 2013 with the application of GMM method for panel data, which demonstrated the beneficial effect and negative impact of economic growth and globalization on the environment respectively and concluded the occurrence of EKC. Zhang et al. (2017) tested the EKC hypothesis in 10 newly industrialized countries (NICs-10) from 1971 to 2013 and proved its existence; in addition, they found the trade openness substantially reduced CO2 emissions while real GDP and primary energy consumption stimulated the emissions. Haseeb et al. (2018) confirmed the existence of EKC phenomenon in BRICS countries and reported no significant causality between globalization, urbanization and CO2 emissions while energy consumption and financial development degraded the environment quality. Phong et al. (2018) scrutinized the roles of globalization in CO2 emissions of Vietnam from 1985 to 2015 by incorporating industrialization, urbanization, energy consumption and GDP per capita with the application of ARDL method, which indicated that energy consumption, industrialization and GDP per capita boosted CO2 emissions in the long run while globalization demonstrated negative effect.

In general, it can be witnessed from the existing literature that the findings concerning CO2 emissions and its determinants are not uniform; rather, they depend on the unique characteristics of each country or region. In this study, the author inspects the dynamic connections between energy consumption, GDP per capita, urbanization and CO2 emissions in the presence of EKC hypothesis for ASEAN countries by including the analyses of globalization and financial development as important factors in economic openness.

## 3. DATA AND ECONOMETRIC METHODOLOGY

### 3.1. Data

This paper employs balanced panel data from 1971 to 2014 for analyzing the impacts of financial development and globalization on environmental degradation as well as testing the EKC effect in some ASEAN countries including Myanmar, Malaysia, Philippines, Singapore and Thailand. The time range is limited by the availability of the data.

There are 6 variables used in this study: CO2 emissions, financial development, globalization, GDP per capita, energy consumption and urbanization. The aforementioned variables (except globalization) are collected from World Development Indicators. Meanwhile, globalization is retrieved from KOF Globalisation Index provided by KOF Swiss Economic Institute. The KOF Globalisation Index was proposed by Dreher (2006) and revised by Dreher et al. (2008); it consists of three dimensions of globalization: Economic, social and political. The first dimension of globalization (economic) reflects flows of goods, capital and services as well as information and perceptions that accompany market exchanges. The second aspect of globalization (social) captures the spread of ideas, information, images and people. The final component of globalization (political) entails the diffusion of policies (Nye and Donahue, 2000). In this article, the author will utilize the aggregate measure of globalization together with each individual component measure. Besides, private sector credit is used as a proxy for gauging the level of financial development (Salahuddin et al., 2017). All variables are converted into natural logarithm to interpret elasticities of the coefficient estimates. Table 1 provides information regarding the variables and their sources.

The descriptive statistics of variables are demonstrated in Table 2.

### 3.2. Econometric Methodology

In order to assess the impacts of globalization and financial development as well as verify the occurrence of EKC for some ASEAN countries, the author employs the CO2 emissions functions based on Shahbaz et al. (2015b), Phong et al. (2018), and Haseeb et al. (2018) as follows:

$$CO2=f(GDP, GDP^2, EC, FD, URB, KOF) \quad (1)$$

$$CO2=f(GDP, GDP^2, EC, FD, URB, KOFe) \quad (2)$$

$$CO2=f(GDP, GDP^2, EC, FD, URB, KOFs) \quad (3)$$

$$CO2=f(GDP, GDP^2, EC, FD, URB, KOFp) \quad (4)$$

Where, CO2 stands for CO2 emissions per capita; GDP denotes GDP per capita computed at the constant price (2010US$); $GDP^2$ means the square of GDP; EC reflects primary energy consumption per capita; FD demonstrates financial development; URB is the urban population share of the total population (%); KOF represents the overall globalization index; KOFe stands for the economic dimension of globalization; KOFs symbolizes the social aspect of globalization; and KOFp is the political component of globalization.

According to Shahbaz et al. (2016b), Dar and Asif (2018), when all variables are transformed to natural logarithm, the log-linear regression equation can smooth out the dynamics of time-series and produce reliable estimations. The equations (1), (2), (3) and (4) can be converted into the log-linear form as follows:

$$\begin{aligned} LCO2_{it} &= \alpha_0 + \alpha_1 LGDP_{it} + \alpha_2 LGDP_{it}^2 + \alpha_3 LEC_{it} \\ &+ \alpha_4 LFD_{it} + \alpha_5 LURB_{it} + \alpha_6 LKOF_{it} + \varepsilon_{it} \end{aligned} \quad (5)$$

$$\begin{aligned} LCO2_{it} &= \beta_0 + \beta_1 LGDP_{it} + \beta_2 LGDP_{it}^2 + \beta_3 LEC_{it} \\ &+ \beta_4 LFD_{it} + \beta_5 LURB_{it} + \beta_6 LKOFe_{it} + \mu_{it} \end{aligned} \quad (6)$$

$$\begin{aligned} LCO2_{it} &= \chi_0 + \chi_1 LGDP_{it} + \chi_2 LGDP_{it}^2 + \chi_3 LEC_{it} \\ &+ \chi_4 LFD_{it} + \chi_5 LURB_{it} + \chi_6 LKOFs_{it} + \nu_{it} \end{aligned} \quad (7)$$

$$\begin{aligned} LCO2_{it} &= \delta_0 + \delta_1 LGDP_{it} + \delta_2 LGDP_{it}^2 + \delta_3 LEC_{it} \\ &+ \delta_4 LFD_{it} + \delta_5 LURB_{it} + \delta_6 LKOFp_{it} + \pi_{it} \end{aligned} \quad (8)$$

Where L stands for the natural logarithm; *i* indicates the number of countries; *t* represents the number of periods; $\alpha_0$; $\beta_0$; $\chi_0$; $\delta_0$ are

**Table 1: Variable description and sources**

| Variable name | Symbol | Description | Unit | Data source |
|---|---|---|---|---|
| Carbon dioxide emissions | CO2 | Carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. | Metric tons per capita | World development indicators |
| Economic growth | GDP | The gross domestic product by the midyear population (GDP per capita) | Constant 2010 US dollars | World development Indicators |
| Energy consumption | EC | It comprises petroleum products, natural gas, electricity, and combustible renewable and waste. | Kg of oil equivalent per capita | World development indicators |
| Financial development | FD | The domestic credit to the private sector | % of GDP | World development indicators |
| Urbanization | URB | Urban population refers to the number of people living in urban areas of a country | Total urban population, % | World development Indicators |
| Globalization | KOF | Includes economic globalization (KOFe), social globalization (KOFs), and political globalization (KOFp) | Index (from 0 to 100) | KOF Swiss economic institute |

Source: Author's collection

the intercepts; $\alpha_k\ (k=\overline{1,6})$; $\beta_k\ (k=\overline{1,6})$; $\chi_k\ (k=\overline{1,6})$; $\delta_k\ (k=\overline{1,6})$ are regression coefficients of the explanatory variables; and $\varepsilon_{it}$; $\mu_{it}$; $v_{it}$; $\pi_{it}$ illustrate the error terms. Under the EKC hypothesis, the signs of $\alpha_1$ and $\alpha_2$ are expected to be positive and negative respectively in order to reflect the inverted U-shaped pattern. Similarly, the former coefficient in each of the three pairs $\beta_1$ and $\beta_2$, $\chi_1$ and $\chi_2$, $\delta_1$ and $\delta_2$ is expected to be positive while the latter's is negative.

To estimate the above regression models, the author considers the following general panel data regression model:

$$Y_{it} = \rho_0 + \rho_1 X_{it} + \omega_{it} \tag{9}$$

The error terms ($\omega_{it}$) in equation (9) involves all unobserved factors possibly affect the dependent variable over time and cross-sectionally. When the unobserved effect equals zero, both unique characteristics between entities and general effects over time are absent, thus enabling the application of Pooled OLS estimation method. Nevertheless, if it is different from 0 or there exists heterogeneity, the OLS estimator is no longer best linear unbiased estimator for equation (9), and therefore, fixed effects model and random effect model are considered to be used. Consequently, equation (9) can be rewritten as follows:

$$Y_{it} = \rho_0 + \rho_1 X_{it} + \lambda_i + u_{it} \tag{10}$$

Where $\lambda_i$ represents the unobservable time-invariant factors; $\mu_{it}$ is the remainder error changing over time and entities. It is of vital importance that one must identify whether $\lambda_i$ correlates with the regressors in the model (Mundlak, 1978). In case the time-invariant factors correlate with the regressors, they must be treated as independent variables and cannot be considered as error term; accordingly, the fixed effects model is appropriately utilized and equation (10) becomes fixed effects model where $\lambda_i$ is the intercept indicating the unique characteristics of the countries (Stock and Watson, 2014). If the time-invariant factors do not correlate with the regressors, they can be regarded as composite error (Maki, 2011).

In this article, the author will estimate 04 fixed effects models denoted as (I), (II), (III) and (IV) as well as 04 random effect models denoted as (V), (VI), (VII) and (VIII). They are listed as follows:

Model (I):

$$\begin{aligned} LCO2_{it} &= \alpha_0 + \alpha_1 LGDP_{it} + \alpha_2 LGDP_{it}^2 + \alpha_3 LEC_{it} \\ &+ \alpha_4 LFD_{it} + \alpha_5 LURB_{it} + \alpha_6 LKOF_{it} \\ &+ \alpha_i \varepsilon_i + \varepsilon'_{it} \end{aligned} \tag{11}$$

Model (II):

$$\begin{aligned} LCO2_{it} &= \beta_0 + \beta_1 LGDP_{it} + \beta_2 LGDP_{it}^2 + \beta_3 LEC_{it} \\ &+ \beta_4 LFD_{it} + \beta_5 LURB_{it} + \beta_6 LKOFe_{it} \\ &+ \beta_i \mu_i + \mu'_{it} \end{aligned} \tag{12}$$

Model (III):

$$\begin{aligned} LCO2_{it} &= \chi_0 + \chi_1 LGDP_{it} + \chi_2 LGDP_{it}^2 + \chi_3 LEC_{it} \\ &+ \chi_4 LFD_{it} + \chi_5 LURB_{it} + \chi_6 LKOFs_{it} \\ &+ \chi_i \nu_i + \nu'_{it} \end{aligned} \tag{13}$$

Model (IV):

$$\begin{aligned} LCO2_{it} &= \delta_0 + \delta_1 LGDP_{it} + \delta_2 LGDP_{it}^2 + \delta_3 LEC_{it} \\ &+ \delta_4 LFD_{it} + \delta_5 LURB_{it} + \delta_6 LKOFp_{it} \\ &+ \delta_i \pi_i + \pi'_{it} \end{aligned} \tag{14}$$

Model (V):

$$\begin{aligned} LCO2_{it} &= \alpha_0 + \alpha_1 LGDP_{it} + \alpha_2 LGDP_{it}^2 + \alpha_3 LEC_{it} \\ &+ \alpha_4 LFD_{it} + \alpha_5 LURB_{it} + \alpha_6 LKOF_{it} \\ &+ \alpha + \tau_{it} + \varepsilon'_{it} \end{aligned} \tag{15}$$

Model (VI):

$$\begin{aligned} LCO2_{it} &= \beta_0 + \beta_1 LGDP_{it} + \beta_2 LGDP_{it}^2 + \beta_3 LEC_{it} \\ &+ \beta_4 LFD_{it} + \beta_5 LURB_{it} + \beta_6 LKOFe_{it} \\ &+ \beta + \upsilon_{it} + \mu'_{it} \end{aligned} \tag{16}$$

**Table 2: Descriptive statistics of variables**

| Country | Statistics | CO2 | GDP | EC | FD | URB | KOF | KOFe | KOFs | KOFp |
|---|---|---|---|---|---|---|---|---|---|---|
| Myanmar | Mean±SD | 0.185±0.057 | 403.388±317.662 | 285.414±20.534 | 6.351±2.806 | 26.380±2.996 | 26.571±3.848 | 36.834±4.083 | 12.41±5.132 | 28.863±6.842 |
| Malaysia | Mean±SD | 4.326±2.267 | 5610.910±2482.244 | 1609.236±796.241 | 90.245±38.366 | 53.830±12.386 | 65.096±10.398 | 62.741±6.274 | 64.909±11.190 | 67.637±14.173 |
| Philippines | Mean±SD | 0.798±0.123 | 1667.717±287.501 | 455.862±25.279 | 29.504±8.734 | 43.600±4.992 | 49.494±11.383 | 44.944±9.829 | 36.167±11.700 | 67.370±14.233 |
| Singapore | Mean±SD | 11.467±2.852 | 26266.350±13615.260 | 3838.243±1636.903 | 85.092±19.802 | 100.000±0.000 | 73.696±7.631 | 88.148±4.536 | 74.742±7.349 | 58.265±11.545 |
| Thailand | Mean±SD | 2.201±1.392 | 2905.441±1487.519 | 957.868±522.855 | 84.498±41.660 | 31.787±7.308 | 50.744±12.736 | 46.057±12.163 | 40.690±13.141 | 65.483±13.222 |

Source: Author's calculations

Model (VII):

$$\begin{aligned} LCO2_{it} &= \chi_0 + \chi_1 LGDP_{it} + \chi_2 LGDP_{it}^2 + \chi_3 LEC_{it} \\ &+ \chi_4 LFD_{it} + \chi_5 LURB_{it} + \chi_6 LKOFs_{it} \\ &+ \chi + \phi_{it} + \nu'_{it} \end{aligned} \quad (17)$$

Model (VIII):

$$\begin{aligned} LCO2_{it} &= \delta_0 + \delta_1 LGDP_{it} + \delta_2 LGDP_{it}^2 + \delta_3 LEC_{it} \\ &+ \delta_4 LFD_{it} + \delta_5 LURB_{it} + \delta_6 LKOFp_{it} \\ &+ \delta + \eta_{it} + \pi'_{it} \end{aligned} \quad (18)$$

Where α; β; χ; δ are the intercepts for all countries and $\tau_{it}$; $\upsilon_{it}$; $\phi_{it}$; $\eta_{it}$ are the within entity (country) error and $\varepsilon'_{it}; \mu'_{it}; \nu'_{it}; \pi'_{it}$ are the between entity (country error).

The Durbin–Hausman–Wu test (also known as Hausman test) is necessary for verifying which of the fixed effects model or the random effect model is more effective (Hausman, 1978). The hypothesis H0 of Hausman test for judging the fixed effects model against the random effect model assumes that there is no correlation between the unobservable time-invariant factors and the explanatory variables. The alternative hypothesis H1 assumes that the aforesaid correlation occurs. If H0 is rejected, the fixed effects model is more effective and more pertinent than the random effects model. If H0 cannot be rejected, the latter model is preferred. The order of computing the two estimators can be reversed, and hence, the aforementioned hypotheses and conclusions about them can be inverted in the Hausman test.

## 4. RESULTS AND DISCUSSION

### 4.1. Results

The author runs both fixed effects model (FE) and random effects model (RE) on balanced panel data. After that, the Hausman test is used to choose appropriate model as a basis for estimation.

Next, the Durbin–Wu–Hausman test is implemented to determine whether fixed effects model (FE) or random effects model (RE) is more effective (Tables 3 and 4). When the null hypothesis is rejected, the FE model is more proper for further estimation and analysis. Nonetheless, the RE model should be selected if the null hypothesis cannot be rejected. Table 5 summarizes the Durbin–Wu–Hausman test results.

From Table 5, regarding the two models (I) and (V), the null hypothesis is rejected (as evidenced by both p-value and chi-squared value), thus the RE model (I) is more effective. Concerning the pair of models (II) and (VI), H0 is also rejected and RE model (VI) is chosen. Next, similarly, the RE model (VII) is more preferable than the FE model (III). Finally, the FE model (IV) is better than the RE model (VIII).

The model analysis result is indicated in Table 6 as follows.

**Table 3: Regression results with fixed effects**

| Model | (I) | (II) | (III) | (IV) |
|---|---|---|---|---|
| Dependent variable | LCO2 | LCO2 | LCO2 | LCO2 |
| LGDP | 2.246*** (12.95) | 2.287*** (12.98) | 2.086*** (11.55) | 2.238*** (12.69) |
| LGDP2 | –0.166*** (–13.76) | –0.164*** (–13.62) | –0.158*** (–13.20) | –0.164*** (–12.79) |
| LEC | 1.133*** (13.39) | 1.091*** (12.96) | 1.152*** (13.47) | 1.115*** (12.48) |
| LFD | 0.180*** (4.34) | 0.178*** (4.19) | 0.195*** (4.83) | 0.202*** (4.91) |
| LURB | 0.201 (1.19) | 0.293* (1.85) | 0.238 (1.50) | 0.384** (2.27) |
| LKOF | 0.335** (2.55) | | | |
| LKOFe | | 0.217** (2.09) | | |
| LKOFs | | | 0.240*** (2.77) | |
| LKOFp | | | | 0.0751 (0.51) |
| Const | –16.95*** (–22.96) | –17.00*** (–22.48) | –16.09*** (–21.81) | –16.69*** (–21.34) |
| N | 220 | 220 | 220 | 220 |
| $R^2$ | 0.8738 | 0.9130 | 0.8842 | 0.8950 |
| F (6, 209) | 228.81 | 226.20 | 230.25 | 221.18 |
| Prob>F | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

*P<0.10, **P<0.05, ***P<0.01. Source: Author’s calculation

**Table 4: Regression results with random effects**

| Model | (V) | (VI) | (VII) | (VIII) |
|---|---|---|---|---|
| Dependent variable | LCO2 | LCO2 | LCO2 | LCO2 |
| LGDP | 1.967*** (10.21) | 1.711*** (9.13) | 1.767*** (7.21) | 2.347*** (14.73) |
| LGDP2 | –0.121*** (–9.64) | –0.105*** (–8.50) | –0.109*** (–7.30) | –0.140*** (–13.54) |
| LEC | 1.007*** (11.51) | 0.897*** (9.51) | 0.969*** (10.61) | 0.868*** (12.03) |
| LFD | 0.294*** (5.70) | 0.179*** (3.52) | 0.216*** (4.20) | 0.359*** (8.62) |
| LURB | 0.921*** (8.77) | 0.535*** (4.31) | 0.738*** (7.09) | 0.695*** (8.94) |
| LKOF | –0.725*** (–4.55) | | | |
| LKOFe | | 0.344** (2.27) | | |
| LKOFs | | | –0.0990 (–0.86) | |
| LKOFp | | | | –0.871*** (–11.44) |
| Const | –15.81*** (–17.76) | –16.40*** (–17.05) | –16.24*** (–15.07) | –15.41*** (–20.99) |
| N | 220 | 220 | 220 | 220 |
| $R^2$ | 0.9704 | 0.9683 | 0.9677 | 0.9799 |
| Wald $\chi^2$ (6) | 6990.40 | 6511.26 | 6375.55 | 10390.09 |
| Prob>$\chi^2$ | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

*P<0.10, **P<0.05, ***P<0.01. Source: Author’s calculation

**Table 5: Results of Durbin – Wu – Hausman test**

| Model | (I) | (V) | (II) | (VI) | (III) | (VII) | (IV) | (VIII) |
|---|---|---|---|---|---|---|---|---|
| | FE | RE | FE | RE | FE | RE | FE | RE |
| Hausman test[1] | FE and RE | | RE and FE | | RE and FE | | FE and RE | |
| $\chi^2$ | 1394.26 | | 2687.36 | | 349.94 | | 80.63 | |
| Prob>$\chi^2$ | 0.0000 | | 0.0000 | | 0.0000 | | 0.0000 | |

FE is the fixed effects model; RE is the random effects model. 1 The order of computation and storage in Stata 15 for the Hausman test

## 4.2. Discussion

From Table 6, financial development positively impacts CO2 emissions, which is analogous to the findings of Boutabba (2014) and Shahbaz et al. (2015b) for India; Farhani and Ozturk (2015) for Tunisia; Al-Mulali et al. (2015) for Europe; Javid and Sharif (2016), Shahbaz et al. (2016b) for Pakistan; Salahuddin et al. (2017) for Kuwait; Solarin et al. (2017) for Ghana; Xing et al. (2017) for China; and Haseeb et al. (2018) for BRICS economies. This implies that financial development probably promotes the development of new projects and activities which in turn boost energy consumption, hence increasing CO2 emissions (Javid and Sharif, 2016). Accordingly, governments of ASEAN countries should discourage money lent to inefficient-energy-consuming activities or projects that potentially harm the environment. Also, financial institutions are recommended to allocate more financial resources to “green” or environmentally friendly projects.

The aggregate measure of globalization accelerates CO2 emissions in ASEAN countries when 1% increase in the overall LKOF causes around 0.335% rise in LCO2. The economic dimension of globalization (LKOFe) also raises LCO2 by nearly 0.344% for each 1% increase, which signifies that economic activities under globalization exacerbates the environmental quality. The social aspect (LKOFs) and political facet (LKOFp) of globalization respectively had negative (–0.0990) and positive (0.0751) coefficients, yet their impacts on CO2 emissions are small and statistically insignificant. It can be argued that globalization, especially the economic dimension, reduces trade and investment barriers, which in turn expands economic activities and aggravates the environmental quality. This is in line with the findings of Cole (2004), Shandra et al. (2009), Shahbaz et al. (2015b), Farhani and Ozturk (2015), Ertugrul et al. (2016), and Shahbaz et al. (2017a; 2017b) when incremental trade activities produce the scale effect that precipitates pollution. As a consequence, the governments play a vital role in improving

**Table 6: Results of empirical analysis**

| Independent variable | Dependent variable | | | |
|---|---|---|---|---|
| | LCO2 | LCO2 | LCO2 | LCO2 |
| LGDP | 2.246*** (12.95) | 1.711*** (9.13) | 1.767*** (7.21) | 2.238*** (12.69) |
| LGDP2 | –0.166*** (–13.76) | –0.105*** (–8.50) | –0.109*** (–7.30) | –0.164*** (–12.79) |
| LEC | 1.133*** (13.39) | 0.897*** (9.51) | 0.969*** (10.61) | 1.115*** (12.48) |
| LFD | 0.180*** (4.34) | 0.179*** (3.52) | 0.216*** (4.20) | 0.202*** (4.91) |
| LURB | 0.201 (1.19) | 0.535*** (4.31) | 0.738*** (7.09) | 0.384** (2.27) |
| LKOF | 0.335** (2.55) | | | |
| LKOFe | | 0.344** (2.27) | | |
| LKOFs | | | –0.0990 (–0.86) | |
| LKOFp | | | | 0.0751 (0.51) |
| Const | –16.95*** (–22.96) | –16.40*** (–17.05) | –16.24*** (–15.07) | –16.69*** (–21.34) |
| N | 220 | 220 | 220 | 220 |
| $R^2$ | 0.8738 | 0.9683 | 0.9677 | 0.8950 |

*P<0.10, **P<0.05, ***P<0.01. Source: Author's calculation

economic conditions, achieving globalization benefits and sustainably protecting the environment.

Energy consumption (LEC) stimulates CO2 emissions by approximately 1.133% for each 1% rise. This is not dissimilar to Pao and Tsai (2010) and Haseeb et al. (2018) for BRICS countries; Jaunky (2011) for 36 high-income countries; Ozturk and Acaravci (2013) for Turkey; Shahbaz et al. (2014), Farhani and Ozturk (2015) for Tunisia; Boutabba (2014) and Shahbaz et al. (2015b) for India; Javid and Sharif (2016) for Pakistan; Dogan and Seker (2016) for OECD countries; Dogan and Turkekul (2016) for USA; Rehman and Rashid (2017) for SAARC countries; Solarin et al. (2017) for Ghana; Shahbaz et al. (2017b) for Japan; and Phong et al. (2018) for Vietnam. The aforementioned findings recommend that the governments of those countries necessitate some energy policies for sustainable development such as: promoting effective and efficient energy use, upgrading obsolete technology towards modernity and efficiency, researching and developing renewable energy and green energy sources and reducing the impacts of energy consumption on the environment.

Finally, the evidence of EKC is confirmed for ASEAN-5 economies. Specifically, GDP per capita makes CO2 emissions grow (as evidenced by the positive coefficient of LGDP exhibited in Table 6) while the square of GDP per capita decreases CO2 emissions (as denoted by the negative coefficient of LGDP2 displayed in Table 6), which implies that the movement of CO2 emissions follows the inverted U-shaped pattern of EKC hypothesis stating that CO2 amount rises and then declines after GDP per capita reaches a certain level. This is consistent with Cole et al. (1997) for 7 countries; Halkos (2003) for OECD and non-OECD countries; Apergis and Payne (2009) for Central America; Jaunky (2011) for Greece, Malta, Portugal, Oman, and United Kingdom; Shahbaz et al. (2013b) for South Africa; Farhani et al. (2014) for 10 MENA countries; Kasman and Duman (2015) for European countries; Cho et al. (2014), Dogan and Seker (2016) for OECD countries; Zaman et al. (2016) for 34 developed and developing countries; Twerefou et al. (2017) for 36 Sub-Saharan Africa countries; Zhang et al. (2017) for 10 Newly Industrialized countries (NICs-10); Pata (2018) for Turkey; Tamazian et al. (2009), Pao and Tsai (2010; 2011), Sinha and Sen (2016), Haseeb et al. (2018) for BRICS countries.

## 5. CONCLUSION

The main objective of this study is to examine the relationship between globalization, financial development, energy consumption, economic growth, urbanization and CO2 emissions in some ASEAN countries with the presence of EKC hypothesis. The author employs panel data regression with the fixed effects and random effects models on annual data of 5 ASEAN countries (Myanmar, Malaysia, Philippines, Singapore and Thailand) over the period 1971-2014. The selection of pertinent models is implemented by Durbin–Wu–Hausman test.

Empirical findings indicate several important results. First, financial development, energy consumption and urbanization have significantly positive connections with CO2 emissions in the long run. Second, globalization boosts CO2 emissions in some ASEAN countries, and the largest magnitude of impact comes from the economic dimension of globalization; meanwhile, social and political aspects of globalization insignificantly lowers and raises CO2 emissions respectively. Third, the evidence of EKC in ASEAN-5 economies is affirmed.

Crucial implications can be recommended for the sampled ASEAN countries. The governments necessitate policies that encourage firms and industries to use energy effectively and efficiently, upgrade technology or adopt new or environmentally friendly energy. The development of energy infrastructure requires both energy security and environmental protection. Regarding the financial resources, the governments should promote the performance of projects that save energy and are harmless to the environment. A vital challenge for the governments is to sustainably control the environmental quality when the upsurge of globalization (especially economic dimension), trade and capital investment activities continues in this highly dynamic region of the world. Besides, the reforms of institution, corruption, legal system and financial security control remain essential issues that need great attentions of ASEAN policy-makers so as to foster globalization, financial development and energy security, which contributes to the sustainable development.

The limitation of this article entails inadequate data for all ASEAN countries. Future studies about this topic may have an advantage when the data for the whole ASEAN region is available. Besides, sources of energy consumption at disaggregated level as well as other proxies for environmental degradation will be the focuses of the author's subsequent research. Also, expanding the study to global level is a worthy attempt in future studies.

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