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Do Electricity Consumption and Economic Growth Lead to Environmental Pollution? Empirical Evidence from Association of Southeast Asian Nations Countries

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ABSTRACT

Nowadays, environmental pollution has become a global problem and common to both developed and developing countries. The purpose of this study is to analyze the environmental pollution during the period from 1990 to 2014 in order to discuss the most important factors can effect environmental quality in a specific region in Asia. Using a panel data, in particular generalized least squares model for the sample with T large, N small examined by Pesaran (2006), Sickles and Horrace (2014), our results that a less developed country has a lower level of environmental pollution than a more developed country. More specifically, countries such as Singapore, Malaysia, Thailand, Indonesia, Philippines, and Vietnam have a positive and significant effect on environmental degradation, but no effect for Myanmar. In regard to environmental quality across year, environmental pollution has become even more urgent over time. Specifically, a negative and significant effect can be found in the period from 2005 to 2014 but insignificant effect in the period from 1991 to 2004, and the magnitude of effect has increasingly increased. Further, electricity consumption and income have a positive and significant effect on environmental pollution. However, although export performance has a negative effect on environmental pollution but this effect was insignificant.

Keywords: Environmental Pollution, Electricity Consumption, Income, Generalized Least Squares
JEL Classifications: E21, Q52, Q54

1. INTRODUCTION

In the trend of global economic integration, the use of energy use has made a significant contribution to support for human lives and the global economy (Tran and Van, 2013). In the 20th century, the fourth industrial revolution has started building on the digital revolution and been marked by emerging technologies, in particular to build up clean energy environment and ensure eco-friendly environment.

Today, environmental pollution has become a global problem and increasingly common to both developed and developing countries. In the industrial society, environment pollution has become such an important problem as economic grows, more energy consumption use and export promotion. The environmental pollution has become increasingly serious in the global to damage health and human being (Tran et al., 2020).

Except Timor-Leste, the Association of Southeast Asian Nations (ASEAN) is a regional inter-governmental organization comprising 10 countries in Southeast Asia. The main member states with more developed economics as Indonesia, Malaysia, Philippines, Singapore, and Thailand (ASEAN 5). Recently, numerous previous studies have used econometric modeling to examine factors influencing environmental pollution across the world. To the best of our knowledge, no study has focused on CO_2

emission in the group of ASEAN countries. As a result, ASEAN is an organization of combination of developing, developed countries, especially most of the low-middle income countries. Therefore, the effects of electricity consumption, income and export performance (EXP) on CO_2 emission are more preferred in this study.

As many previous studies have compared numerical modeling of the factors affecting environmental pollution. Four driving engines include intensity of emission, production structure in the economy, export formation, and EXP; have been compared for their present to the increase of CO_2 emissions (Wu et al., 2019). In general, the theoretical literature reviews has been discussed to find out the effect of energy consumption (Yildirim et al., 2014; Muhamad, 2019; Yang et al., 2019), and income (Wasti and Zaidi, 2020; Munir et al., 2020; Abokyi et al., 2019; Mikayilov et al., 2018) on the expansion of environmental pollution. Furthermore, Wu et al. (2019); Richter and Schiersch (2017); Zhao et al. (2017) described that EXP is also thought to be the major root cause of the environmental pollution. Therefore, encouraging to use more renewable energy should be certainly adopted in order to reduce pollution (Cherni and Jouini, 2017).

For all of reasons discussed, the study is to analyze the effects of electric power consumption (EC), income (EG), and EXP on carbon dioxide emission. The general objectives of this present work are (i) to analyze the EC, EG, and EXP and its impact on carbon dioxide emission (ii) to discover the major conclusion in the case of ASEAN countries.

Electric power consumption, income, and export are the most important factors that play a leading task in the process of increasing pollution. The present empirical work is a significant contribution in review of literature that focuses on the comprehensive relationship among EC, EG, and EXP, carbon dioxide emission in the case of ASEAN countries in Asia. Further, this study provides information to all, especially for the policy makers, researchers and the ASEAN's government to control carbon dioxide emission in order to maintain a sustainable economic development.

The rest of the paper is organized as follows: Section 2 presents a brief of ASEAN context. Section 3 presents the literature review of previous studies whereas Section 4 discusses the data and data sources, methodology and techniques used in the study. Further, Section 5 and Section 6 indicate the results and some discussions. Finally, Section 6 states the main conclusion.

2. ASEAN BACKGROUND

In most ASEAN countries, the consumption of electricity (EC) during the period between 1990 and 2014 had steadily increased at a growth rate of 7.4% (Table 1). It demonstrates that the quality of lives and production ability in the area has been increasingly improved. Further, Indonesia and Philippines' electricity consumption had increased at the lowest growth rate in this period with roughly 2.4% and 2.8%, by contrast, Cambodia and Vietnam had significantly generated in growth rate with roughly 17.1% and 11.9%, respectively. Regarding electricity consumption per capita, the largest EC countries in the area are Singapore, Malaysia and Thailand. For example, in 1990, 2002, 2014, EC in Singapore amounted to approximately 4983.04; 7756.31; and 8844.68 kWh per capita, similarly, EC in Malaysia amounted to approximately 1157.36; 2820.55; and 4651.95 kWh per capita. Comparing these situations with those of Myanmar and Cambodia, it is evident that EC per capita in these countries is the lowest in ASEAN community. For example, EC in Myanmar and Cambodia amounted to approximately 57.17; 13.51 in 1995; 73.03; 50.32 in 2002; and 215.29; 271.36 kWh per capita in 2014. In addition to other members in ASEAN, i.e. Indonesia, Vietnam, Thailand, and Philippines predominantly lag behind Singapore and Malaysia, but further go before Myanmar and Cambodia.

In terms of EXP (Table 2), the EXP shows growth during the period between 1990 and 2018. The data describes an upward trend in the EXP for ASEAN countries during the research time. The main ASEAN exporters include Singapore, Thailand, Vietnam, Malaysia and Indonesia with export value of approximately 642.27; 332.44; 258.48; 246.47; and 208.73 billion US dollars in 2018 that account for 95 percent export value in the region. Compared with other main exporters, although Philippines, Laos, Myanmar and Cambodia continued to expand more new markets to export their products with export of approximately 90.4; 6.21; 15.76; and 18.41billion US dollars but they have still lagged behind other major exporters in the region.

In terms of economic growth in ASEAN countries, Table 3 describes that GDP in ASEAN had been significantly increased by the time. However, ASEAN countries divided into two groups: less developed economies as Cambodia, Laos, Myanmar and Vietnam (CLMV) and more developed economies in the region as Indonesia, Philippines, Malaysia,

Table 1: Electric power consumption in ASEAN (kWh per capita)

Variable	1990	1996	2002	2008	2014
Indonesia	162.52	297.20	417.49	570.06	811.90
Cambodia	N/A	20.03	50.32	114.59	271.36
Myanmar	44.10	57.63	73.03	94.15	215.29
Malaysia	1157.36	2187.87	2820.55	3286.09	4651.95
Philippines	361.04	428.54	522.29	584.59	696.34
Singapore	4983.04	6312.68	7756.31	8720.02	8844.68
Thailand	709.55	1380.05	1617.56	2105.44	2538.79
Vietnam	95.25	179.83	377.55	802.55	1423.68

Source: World Development Indicators (2019)

Table 2: Export performance in ASEAN (bn US dollars)

Variable	1990	1996	2002	2008	2014	2018
Indonesia	29.30	56.79	65.83	146.06	198.82	208.73
Cambodia	0.02	0.81	2.37	5.02	11.98	18.41
Laos	0.10	0.35	0.48	1.49	4.04	6.21
Myanmar	0.32	1.37	2.42	6.26	13.15	15.76
Malaysia	32.66	92.12	108.23	229.97	249.54	246.47
Philippines	11.43	33.49	27.04	47.73	75.32	90.4
Singapore	67.49	169.13	170.35	338.93	604.39	642.27
Thailand	29.23	71.42	81.44	208.36	278.58	332.44
Vietnam	2.40	9.50	19.65	69.69	161.19	258.48

Source: World Development Indicators (2019)

Table 3: GDP in ASEAN (bn US dollars)

Variable	1990	1996	2002	2008	2014
Indonesia	29.30	56.79	65.83	146.06	198.82
Cambodia	0.02	0.81	2.37	5.02	11.98
Laos	0.10	0.35	0.48	1.49	4.04
Myanmar	0.32	1.37	2.42	6.26	13.15
Malaysia	32.66	92.12	108.23	229.97	249.54
Philippines	11.43	33.49	27.04	47.73	75.32
Indonesia	67.49	169.13	170.35	338.93	604.39
Thailand	29.23	71.42	81.44	208.36	278.58
Vietnam	2.40	9.50	19.65	69.69	161.19

Source: World Development Indicators (2019)

Singapore and Thailand. Importantly, economic growth in ASEAN countries has been significantly expanded during this research period of time, at a level of 5.97 percent on average. Arguably, the development level among economies in the region still exists at a big gap. The per-capita GDP among economies is highly different, the GDP per capita of Singapore in 2018 was $64,579 compared to Cambodia in 2018 was $1504 with a 43-fold difference. Furthermore, the relatively population size of ASEAN members has been relatively dissimilar. It is specific that Indonesia is fifty times larger than Singapore or Laos regarding population size.

3. LITERATURE REVIEW

Recently, a large number of existing studies have used econometric modeling to examine factors influencing environmental pollution. In most studies, electricity consumption is one of the most important factors in each country. Each government has certainly allocated considerable amount of financial resources from local and foreign investment to expand more electricity projects (Van, 2020). The production of electricity in most countries and ASEAN countries as well has strongly increased during over last 30 years in relation to World Development Indicators (2019).

The upcoming years have been brought such an extraordinarily good opportunity for developing, developed countries and the world. The process of urbanization and in particular to industrialization has been considered as the major reason for environmental pollution. Pollution has a trade-off with economic development. In the process of developing, nations are often reliant on the exploitation of natural resources in order to make comparative advantage and build up revenue. The impact of electricity consumption, income and EXP on environmental pollution has been widely discussed (Wasti and Zaidi, 2020; Munir et al., 2020; Mikayilov et al., 2018; Cai et al., 2018; Cherni and Jouini, 2017; Wu et al., 2019; and Zhao et al., 2017). Specifically, the various theoretical literatures have been constructed to find out the possible existence of an effect of electric power consumption (Muhamad, 2019; Yang et al., 2019; Cai et al., 2018) and income (Wasti and Zaidi, 2020; Munir et al., 2020; Abokyi et al., 2019; Mikayilov et al., 2018; Cherni and Jouini, 2017; Tang et al., 2016) on increase of pollution. As suggested in some studies on EXP, (Wu et al., 2019; Richter and Schiersch, 2017; Zhao et al., 2017; Michieka et al., 2013 and Xu et al., 2011) indicated that EXP can play a vital role in changing the environmental pollution.

In the context of economic development, sustainable development is the foundation for fast development in terms of macroeconomic stability, income enhancement, and environmental protection. Using more carbon-intensive fuels, in particular to generate electricity to supply consumption demand has led to various environmental concerns, particularly regarding rapid growth in CO_2 emissions in recent years. Under this dilemma, the power sector has significantly experienced on structural shifts with a quick expansion of using more renewable energy in the energy source. As suggested in Wasti and Zaidi (2020), using the time-series data retrieved from World Bank in the period of 1971-2017 in Kuwait, the study found the relationship between energy consumption and CO_2 emission, so-called for environmental pollution. Further, an effect from GDP to CO_2 emissions can be also found.

According to Munir et al. (2020) in the case of 5 members in ASEAN in the years of 1980- 2016, for a group of Philippines, Malaysia, Thailand, and Singapore, there exists a unidirectional causality from economic growth to CO_2 emission. In addition to Indonesia, the study has not found any evidence. More discussion about this study, Munir et al. (2020), the test used in the dataset indicates that a misleading inference about Environmental Kuznets Curve can be present and supported by this study.

Similarly, Mikayilov et al. (2018) conduct a study on the link between economic growth and CO_2 emission through a times-series data over 1992-2013 in Azerbaijan. In the long run, economic growth has a positive and significant in relation to the emission, and Environmental Kuznets Curve does not appear in Azerbaijan. To reduce environmental pollution and relieve bad consequences of pollution, the country needs to use energy efficiency and use the instruments of carbon pricing in operation and trade, and enhancement in social awareness. To conduct on the specific sector, Abokyi et al. (2019) further demonstrated that a U-shaped relationship between growth in the industry and carbon dioxide emissions can be found. Focused on a group of 68 countries, i.e. developed, developing and emerging, and the Middle East and North Africa (MENA) economies, Muhamad (2019) conduct a study based on a panel data in the period of 2001-2017. First, income increases the CO_2 emission in developed and MENA countries. Second, because emissions of carbon dioxide certainly increase in countries due to energy consumption growth, thus environmental pollution can be reduced in the context of countries using environmentally friendly technologies.

Using a time-series data in G7 countries, Cai et al. (2018) analyzed the linkages among energy consumption, income and CO_2 emissions. Results are a bi-directional causality between consumption of clean energy and CO_2 emissions can be found for the case in Germany. However, for the US, Cai et al. (2018) also described that there is a unidirectional causality from energy consumption on CO_2 emissions. Further discussed on policy recommendations in G7 countries, it is evident that promotion of efficient energy-use policy can significantly reduce environmental pollution.

From the strategy to conduct China's economic reform in the late 1970s and early 1980s, and a plan to shift its economy from a command economy to a mixed economy, based on major engines to boost a rapid economic growth, process of urbanization and in particular to industrialization has been considered as the major reason for environmental pollution. China has increasingly incurred a high cost of environmental pollution. Yang et al. (2019) employed the approach of Kaya identity and the method of Logarithmic Mean Divisia Index (LMDI) to discuss factors affecting of carbon dioxide emissions between 1996 and 2016, it is found that the economic activity as one of the main factors to generate carbon emissions, while on the contrary, energy intensity is the most powerful repressor. Similarly confirmed by Cai et al. (2018), Yang et al. (2019) also supported that changes in the energy structure and development of clean energy can positively restrain carbon emissions growth. Further, Yang et al. (2019) mentioned that using more imported electricity is a good strategy in order to reduce effects of carbon emissions, a risk from the host country in this case is originally from the home country of exported electricity.

Cherni and Jouini (2017) investigated the linkages between environmental pollution, income, and renewable energy consumption in Tunisia. They used Johansen cointegration approaches in an ARDL framework. The Granger causality tests indicate a bidirectional relationship between GDP and CO_2 emissions can be sought. Further, Cherni and Jouini (2017) indicated that the success of energy transition policy can positively benefit on economic growth and environment clean, in which, encouraging to use more renewable energy should be certainly adopted.

Regarding EXP, various empirical studies have been focused on the relationship between EXP and CO_2 emissions. As suggested in Wu et al. (2019), China has performed some sectoral adjustments in the export to transform economic structure. There are two-way impact of export effects and CO_2 emissions. Specifically, increasing export of service, and transport equipment as well as decreasing export of textile can be effective for China's economy and reduction for CO_2 emission. Similarly, Richter and Schiersch (2017) indicated that a positive effect between intensity of export and CO_2 emissions can be found in Germany. Further, environmental premium of German exporters certainly holds for manufacturing firms in the country at the double-digit level.

Zhao et al. (2017) conduct a study on China and USA, using CO_2 emission LMDI methods on a time-series data from 1995 to 2009, CO_2 emissions in export have increasingly decreased by over time, from 4.20 Mt/billion US dollars in 1995 down to 2.48 in 2009 in China, and 0.66 to 0.33 in USA, respectively. However, CO_2 emissions per value added in China is a couple of times larger than that of the USA. More discussion on the sectoral level, both transport and industrial sectors are top sectors with large CO_2 emissions in China and USA's exports. This evidence is further confirmed in the study of Michieka et al. (2013) and Xu et al. (2011). The changes in GDP can predominantly determine variability in exports in the future and CO_2 emissions Michieka et al. (2013)

4. DATA SOURCES AND METHODOLOGY

4.1. Data Sources

This study uses annual data for the period between 1990 and 2014. The study uses a panel dataset of electric power consumption (kWh per capita), income, and export value in ASEAN countries. The data were obtained from the World Development Indicators (WDI), Department of Statistics at the relevant countries used in the study. The income (EG) is US dollars; electric consumption (EC) is in kWh per capita; and exports of goods and services (% of GDP) is in percent.

4.2. Research Methods

4.2.1. Pooled OLS, fixed effect method (FEM) and random effect method (REM)

The present study adopts three techniques such as Pooled OLS, FEM, and REM. As suggested in empirical studies, although the Pooled OLS estimation is simply an OLS technique run on the panel data, but Pooled OLS can apply for the estimation in order compare among methods the study used. Further, because of existence of a lot of basic assumptions as orthogonality of the error terms that are violated, so this technique may be rejected in some situations. In general, Pooled OLS analysis is most suitable when each observation in the study is independent of any other.

With respect to REM, REM can certainly solve this problem by implementing an individual specific intercept in the model, which is assumed to be random. It implies full exogenity of the model. However, if the model is assumed to have some endogenity issues, the estimation in relation to FEM is the best choice and made the results that are the best consistent estimates but the individual specific parameters will be certainly vanished. Further, for test whether FEM rather than REM is needed, it is evident that it can be checked with the Hausman test.

4.2.1.1. Panel data with T large, N small

Panel data have a large number of techniques to perform models, in particular from databases retrieved by a small number of entities observed in a long time. In argument, the length of time T and entity N could significantly impact results under the specific estimations. Therefore in order to solve problems with the length of N and T, some previous studies have indicated some ideas that can help in solving with these differences. In particular to the scenery with N small, T large, previous studies demonstrate to treat this kind of equations based on a system of a seemingly unrelated regression equations (SURE). It is further to discuss, Pesaran (2006) demonstrated that the study need to estimate the system by generalized least squares (GLS) techniques at a following step.

According to Wooldridge (2010), a panel data with T that is large, and especially when N is not very large, the study must pay attention to the estimator of fixed effects instead of random effects method. Even though exact distributional results possess for any entity N and the length of time T under the assumptions based on classical fixed effects, a result can be easily sensitive to infraction of assumptions at N is small and T is large. Further, Chudik et al. (2011) also confirmed that in the specific situation, when N is much smaller and in connection with T, the errors are uncorrelated with the regressors cross-section dependence, using SURE can be modelled. As suggested by Sickles and Horrace (2014), GLS estimators, and Hausman test, can be used without any adjustments for the data with large T.

For T large, N small, the study is to consider as follows:

$$y_{i,t} = \alpha + \beta x_{i,t} + \varepsilon_{i,t}$$

In the case of heteroscedasticity errors, it is evident that $\sigma_i^2 \neq \sigma^2$, entities with large errors will dominate the fit. For this reason, a correction is necessary. It is as similar as a GLS estimator, which can be performed to correct it.

Describe the Figure 1:

- Step 1: Select either FEM or pooled OLS based on F-test
- Step 2: Select either FEM or REM based on Hausman test
- Step 3: The model correction based on GLS and also for T large, N small.

4.3. Methodology

Following the previous studies, the discussion of electricity consumption, income and EXP has been investigated in a large number of developed and developing countries, and countries in transition. The functional form specification of standard long liner has been focused according to theoretical consideration. Followed by the studies of Wasti and Zaidi (2020); Munir et al. (2020); Mikayilov et al. (2018); Cai et al. (2018); Cherni and Jouini (2017); Wu et al. (2019); and Zhao et al. (2017), and other empirical studies, the model equation for the estimation is written as follows:

$$Y = f(X_1, X_2, X_3 \ldots X_n) \quad (3.1)$$

Here, the logarithmic transformation of equation (3.1) is specifically given by:

$$\ln CO_{2i,t} = \alpha_0 + \alpha_1 \ln EC_{i,t} + \alpha_{21} \ln EG_{i,t} + \alpha_3 \ln EXP_{i,t} + \alpha_4 DEV_{i,t} + \alpha_5 D_{i,t} + \varepsilon_{i,t} \quad (3.2)$$

Here, the logarithmic transformation of equation (3.1) based on Environmental Kuznets Curve (EKC) is specifically given by:

$$\ln CO_{2i,t} = \alpha_0 + \alpha_1 \ln EC_{i,t} + \alpha_{21} \ln EG_{i,t} + \alpha_{22} \ln EG^2_{i,t} + \alpha_3 \ln EXP_{i,t} + \alpha_4 DEV_{i,t} + \alpha_5 D_{i,t} + \varepsilon_{i,t} \quad (3.2)$$

Where:

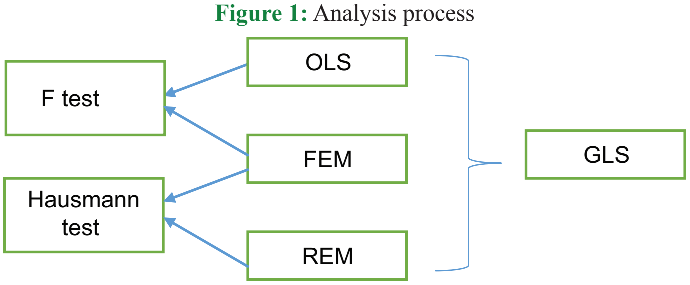
$\alpha_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4$, and α_5 are estimation coefficients.

$\varepsilon_{i,t}$ is error of country i in year t.

ln CO_2 = is a dependent variable, reflecting the level of environmental pollution and is calculated by the natural logarithm of CO_2 emission per capita (metric tons).

lnEG = is the dependent variable, reflecting the income and is calculated by the natural logarithm of gross domestic product per capita.

Figure 1: Analysis process



lnEC = is the dependent variable, reflecting the energy consumption, and is calculated by the natural logarithm of electricity power consumption in kWh per capita.

lnEXP = is the dependent variable, reflecting the EXP, and is calculated by the natural logarithm of exports of goods and services (% of GDP) in ASEAN countries.

DEV= is the dummy variable, reflecting the level of economic development of a country.

$D_{i,t}$= is the dummy variables.

5. RESULTS AND DISCUSSIONS

5.1. Results of Econometric Modeling

In this section, the study will immediately discuss results of the estimated model in the case of nine ASEAN countries. Firstly, it is to estimate based on Pooled OLS, FEM, and REM. Secondly, it is to implement the diagnostics test for the estimation. Finally, all results are focused, we can explain the best model found in the study. Finally, the study will deeply discuss the estimated model results and analyze the conclusion.

5.1.1. Descriptive statistics

Table 4 describes the descriptive statistics of the variables used in the study regarding their mean, standard deviation, minimum, and maximum values in ASEAN countries. This analysis is based on panel data that are multi-dimensional data involving measurements over time. The results presented in Table 4 describe that, the rate of exports of goods and services has changed from 0 to 229% GDP in ASEAN countries. It considers that few countries have a large trade openness in recent years, i.e. Singapore, Vietnam, and Malaysia. Further, there is a huge gap in GDP per capital among countries. Singapore is a high income country with GDP per capita 57,562 US dollars in 2014 compared to Cambodia 1093 US dollars, Myanmar 1251 US dollars at the same time. Regarding CO_2 emission per capita, this indicator in the region has significantly increased. It indicates that a higher level in development and the time was connected with CO_2 emission, in particular Singapore, Malaysia, and Thailand had known as the top countries with CO_2 emission per capita, 10.30 metric tons, 8.13 metric tons, and 4.62 metric tons in 2014, respectively.

In respect to multicollinearity analysis, Gujarati (2004) described that the multicollinearity existence can be found if correlation coefficient is 0.8 and more or Variance Inflation Factor (VIF) is more than 10. In this situation, severe multicollinearity can be exactly present because absolute value of pairwise correlations between variables may be relatively high. Based on VIF that are used in the study, the result of VIF shown in Table 5 shows that the

Table 4: Descriptive statistics of variables used in the study

Variable	Obs	Mean	Std. dev.	Min	Max
EXP	225	60.2949	53.6888	0.00	228.99
EC	195	1742.047	2441.102	13.51334	8844.688
EG	225	5023.628	10475.36	0	57562.53
DEV	225	0.6666667	0.4724556	0	1
CO_2	225	2.697709	3.709814	0.0499442	18.04087

Source: Analyzed by the author

VIF of all independent variables is <10. Therefore, it is concluded that there is no multicollinearity problem in the models.

5.1.2. Regression models

The various estimation approaches were applied to the panel data, including; FEM, pooled OLS and REM. First, the study conducts the following panel data and also test of diagnostics to identify the best regression model for the study (Table 6).

Based on the F test, we have:

- H_0: The null hypothesis is that the preferred model is fixed effects
- H_a: The alternate hypothesis is that the model is OLS.

Fixed and pooled OLS effect. The result is from the fixed effect panel model. Because F (7,173) = 60.9, and also, Prob. >F is smaller than 0.05. Then the null is rejected, choose the Pooled OLS, instead of fixed effect model.

Based on the Hausman test, we have (Table 7):

- H_0: The null hypothesis is that the preferred model is random effects
- H_a: The alternate hypothesis is that the model is fixed effects.

Prob. >F is smaller than 0.05. Then the null is rejected, choose the fixed effects, instead of fixed random effects. In conclusion, pooled OLS is the most suitable in this study. However, the diagnostics test stated that the model exists autocorrelation and heteroskedasticity. In order to correct diagnostics in the model, GLS estimator is more preferred. This is in line with the suggested in the studies of Pesaran (2006), Sickles and Horrace (2014) for a panel data with T large, N small (Tables 8 and 9).

Table 5: Multicollinearity test

Variable	VIF	1/VIF
lnEC	7.39	0.135236
lnEG	7.00	0.142858
LnEXP	1.57	0.637839
Mean VIF	5.32	

Source: Analyzed by the author

Table 6: Estimated results

Variable	Pooled OLS	FEM	REM
Dependent variable			
ln CO_2			
Independent variable			
lnEC	0.7393	0.4954	0.5369
	(0.000)***	(0.000)***	(0.000)***
lnEG	−0.0487	0.8082	0.6480
	(0.784)***	(0.000)***	(0.000)***
lnEG2	0.0017	−0.0538	−0.0438
	(0.864)***	(0.000)***	(0.000)***
lnEXP	0.1005	−0.0540	−0.0332
	(0.000)***	(0.020)***	(0.160)***
DEV	0.3197	omitted	0.5778
	(0.000)***		(0.061)***
−cons	−4.7593	−5.5269	−5.7546
	(0.000)***	(0.000)***	(0.000)***

Source: Analyzed by the author. *, **, and *** indicate significance level of 10%, 5% and 1%.

6. DISCUSSION OF RESULTS

Regarding the estimation results with the approach of Generalized least squares – GLS, the study concludes some important results as follows:

Table 8 depicts the results of the generalized least squares model on CO_2 emission in ASEAN countries. The results show that electric power consumption had a positive but significant effect on CO_2 emission (P = 0.000). This implies that a 1 percent increase in electric power consumption will certainly generate at least 0.65 percent in CO_2 emission. A number of previous studies have been similarly found this evidence, i.e. Muhamad (2019) conduct on a study in MENA countries, carbon dioxide emission can be increase because of energy consumption growth; Cai et al. (2018) in the US.

Similarly, economic growth denoted by GDP per capital also had a positive and significant influence on CO_2 emission (P = 0.026). The higher income in turn affects CO_2 emission. Moreover, increasing environmental pollution in ASEAN is brought about more economic development. This finding is supported by Mikayilov et al. (2018) in Azerbaijan, and Muhamad (2019) in developed and MENA countries. In addition, Yang et al. (2019) also indicated that economic performance is one of the major factors to grow carbon emissions.

In regard to EXP and its impact on environmental pollution, no effect can be found. It means that the policy of export expansion in ASEAN had not found any effects on the environment. This is not in relation to numerous previous studies. Wu et al. (2019) studied in China, Richter and Schiersch (2017) in Germany with a positive effect.

Table 7: Hausman test

	(b) fem	(B) rem	(b-B) Difference
lnEC	0.495408	0.565787	−0.07037
lnEG	0.80824	0.57363	0.23460
lnEG2	−0.05385	−0.039195	−0.01466
lnEXP	−0.05408	−0.03152	−0.022558
Chi-square (4)	122.00		
Prob.> Chi-square	0.000		

Source: Analyzed by the author

Table 8: Estimated results

	GLS	GLS	GLS
Dependent variable			
ln CO_2			
Independent variable			
lnEC	0.6526	0.6705	0.6828
	(0.000)***	(0.000)***	(0.000)***
lnEG	0.1379	−0.1279	0.0906
	(0.001)***	(0.523)	(0.026)**
lnEG2		0.0180	
		(0.182)	
lnEXP	−0.010	−0.010	0.0004
	(0.596)	(0.576)	(0.843)
DEV			0.2150
			(0.0004)***
−cons	−4.8284	−3.9825	−4.8648
	(0.000)***	(0.000)***	(0.000)***

Source: Analyzed by the author. *, **, and *** indicate significance level of 10%, 5% and 1%. GLS: Generalized least squares

Table 9: Estimated Results, across the country and year

	GLS	GLS
Dependent variable		
ln CO_2		
Independent variable		
lnEC	0.4627 (0.000)***	0.6164 (0.000)***
lnEG	0.1388 (0.000)***	0.2538 (0.000)***
lnEXP	−0.004 (0.815)	0.005 (0.977)
−cons	−4.2499 (0.000)***	−5.2951 (0.000)***
Country		
Indonesia	0.8352 (0.000)***	
Malaysia	1.1190 (0.000)***	
Myanmar	−0.1595 (0.266)	
Philippines	0.2361 (0.011)***	
Singapore	1.1154 (0.000)***	
Thailand	0.8841 (0.000)***	
Vietnam	0.4250 (0.000)***	
Year		
1991		−0.0235 (0.457)
1992		−0.0264 (0.542)
…		
2004		−0.1375 (0.110)
2005		−0.1835 (0.038)**
2006		−0.2704 (0.003)***
…		
2013		−0.4869 (0.000)***
2014		−0.4527 (0.000)***

Source: Analyzed by the author. *, **, and *** indicate significance level of 10%, 5% and 1%. GLS: Generalized least squares

However, the level of economic development in ASEAN strongly affected CO_2 emission. A country obtained a higher income could positively generate more pollution than its counterparts. Further, Table 9 indicates the results of generalized least squares model on environmental pollution across countries. The countries such as Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam have a positive and significant effect on CO_2 emission, and the coefficients are significant at 1% level; except for Philippines, the coefficient has significant level of 5%. In the case of Myanmar, a negative effect can be found but insignificant.

In order to differentiate CO_2 emission across year, the period from 1991 to 2004 has negative relation to CO_2 emission, but the coefficients are insignificant at 10%. Further, the period from 2005 to 2014 is negatively correlated with CO_2 emission, and the coefficients are significant at 5%. Additionally, the magnitude of this effect could be continuously expanded at this period, indicating that the level of environmental pollution has been seriously redoubled. This result is association with Zhao et al. (2017) conduct a study on China and USA. Both two countries, by the time CO_2 emissions in relation to EXP have increasingly decreased by over time, from 4.20 Mt/billion US dollars in 1995 to 2.48 in 2009 in China, and 0.66 to 0.33 in USA, respectively.

7. CONCLUSION

The objective was to ascertain the influence of electric power consumption, income and EXP on the environmental pollution in ASEAN countries during the period from 1990 to 2014. Using a panel data, for specific situation in this data, we follow fixed effects, random effects, ordinary least squares, and in particular generalized least squares model for the sample with T large, N small examined by Pesaran (2006), Sickles and Horrace (2014).

Based on the analysis the study concluded that electric power consumption and income have a positive and significant effect on CO_2 emission but income effects are larger. A 1 percent increase in electricity consumption, and income had generally generated roughly at least 0.65 percent and (0.09-0.14) percent in CO_2 emission. In addition, the policy in every country promoted EXP has insignificant influence on CO_2 emission and recommended enhancement of export expansion to the economy in the ASEAN countries due to some export spillovers from export-led growth.

Deeply had a discussion about CO_2 emission across year, the period from 1991 to 2004 has negative and insignificant relation to CO_2 emission, but the negative effect can be found in the period from 2005 to 2014 with a significant level of 5 percent. In addition to magnitude, the environment has been increasingly polluted by the time. Further, countries such as Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam have a positive and significant effect on CO_2 emission, but no effect for Myanmar. It is further discussed the environmental quality has been gradually worsened over time. Accordingly, ASEAN government should ensure in environmental protection and sustainable development, promulgate more environmental technical regulations and laws on environmental protection in the region.

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