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Sustainability in ASEAN Countries: The Role of Financial Development in Climate Change

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Abstract

Higher financial development and economic growth leads to higher production and consumption of a nation. This is because when a country is developed, the demand for infrastructure will increase which could significantly affect the country's environment. The main aim of this paper is to explore the link between energy efficiency, sustainable economic growth, population and financial development in five ASEAN countries (Malaysia, Thailand, Indonesia, Philippines and Vietnam). Panel data analysis was employed and the results show that financial development, economic growth, population and renewable energy are important factors in influencing climate change. Based on the results, increasing financial development, higher energy use, high population and increasing economic growth will generate more CO2 emissions and contribute to climate change. Thus, there are several policies suggested to balance the relationship between financial development and carbon emission levels, which should be considered and implemented by governments and policy makers in order to improve the environmental quality in ASEAN countries. In conclusion, in the five selected ASEAN countries, financial growth plays an important role in highlighting climate change issues. Many past studies have focused on the impacts of renewable energy consumption, population, economic growth and foreign direct investment on climate change. This study narrows the gap that exists in the literature by focusing on financial development, which is able to foster vigorous economic growth, especially in ASEAN countries. Overall, the results from the fixed effects estimates show that financial development is a significant factor and has a positive contribution towards climate change.

Keywords: Sustainable development, Economic growth, ASEAN, Financial development, CO2 emissions, Climate change.
JEL Classification: Q01, R11, O57, O16, Q53, Q54

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Contents

Contribution of this paper to the literature
This study contributes to existing literature by examining the link between energy efficiency, sustainable economic growth, population, and financial development in five ASEAN countries.

1. Introduction

Developing an economy includes growing the financial sector through developing and increasing institutions, instruments and markets that support huge investments, which will, in turn, lead to poverty reduction. Financial development facilitates the availability of information on potential successful investments and efficient resource allocation. In addition, expanding financial access cultivates complex productivity in the sector by introducing systemic reform through creativity and welfare benefits for the economy as a whole. Financial development can be described as the development of the size, efficiency and stability of the financial markets, along with the growth of access to financial markets, which can have multiple economic benefits (Guru & Yadav, 2019). Regarding macroeconomic factors, such as foreign direct investment (FDI), population and economic growth, studies have shown that they can also contribute to climate change. This is because most of the ASEAN countries are still developing and they will attempt to enhance their economic condition by increasing development activities, such as deforestation, that will contribute to environmental degradation.

The impact of climate change is a major concern for ASEAN countries. A report by the Intergovernmental Panel on Climate Change (IPCC) in 2014 stated that the human influence on climate is obvious. Over the last century, the emission of greenhouse gases in Southeast Asia has become the highest in history. The average temperature trends in Southeast Asia have been increasing by 0.1–0.3°C per decade over the last five decades (Asean Cooperation Environment, 2017). The countries in Southeast Asia are the most vulnerable in the world to the impacts of climate change. Malaysia, Thailand, Indonesia, Vietnam, Myanmar, the Philippines and Cambodia are forecasted with the rankings, which show that these seven out of the twenty Southeast Asian countries are more susceptible to the impacts of climate change (ASEAN State of Climate Change Report, 2021). According to the Global Climate Risk Index 2019, Thailand and Vietnam were listed in the top ten countries most affected by extreme weather in 2017. This shows the seriousness of climate change in the ASEAN region. The effects of climate change include the increase in the rate of occurrence of heat waves, droughts and extreme rainfall, and an increase in sea levels, floods and tropical cyclones.

Regarding renewable energy, Yu (2019) states that the ASEAN region is lagging behind other regions in the development of environmental, social and corporate governance (ESG) infrastructure, especially renewable energy. In ASEAN, Vietnam and the Philippines have not put much effort into the development of ESG so far. According to Chen, Wang, & Zhong (2019), renewable energy consumption and carbon dioxide emissions have a negative relationship. However, ASEAN countries have the lowest renewable energy consumption among Indonesia, the Philippines and Thailand (Vikniswari, Ridzuan, Khan, Abdullah, & Mohamad, 2019b). Therefore, ASEAN countries are encouraged to develop its ESG infrastructure. The problem of environmental degradation has become worrying in the ASEAN region. Hence, there is an urgent necessity to carry out a study to identify the significant determinants that contribute to climate change so that actions can be taken in the hope of a better environment in the future.

This study was carried out to determine the factors affecting climate change in five ASEAN countries—Malaysia, Thailand, Indonesia, the Philippines and Vietnam. These five countries are considered to be developing countries. The period of this study ranges from 2006 to 2015. The Environmental Kuznets Curve (EKC) hypothesis is used to explain the environmental changes in response to a country's change in income. According to Dinda (2004), based on the EKC, the environment changes faster in developing countries. The data used in this study is based on the climate change issues and data availability for the selected countries.

Factors such as foreign direct investment (FDI), population, economic growth and renewable energy have been studied before as major determinants that contribute to climate change. However, there are only a few studies that explore the impact of financial development on climate change in developing countries, making it a necessary area to investigate. According to Sadorsky (2010), financial development will stimulate foreign direct investment (FDI). This means that more investors from overseas will invest in a country. For instance, foreign investors may build factories for the production of their goods. Thus, a deeper investigation is necessary so we must extend the model by adding a variable such as financial development. This will be the gap variable of this research due to limited available literature.

2. Literature Review

In Environmental Kuznets Curve (EKC) applications, carbon dioxide emissions are the most applied emissions (Tutulmaz, 2015). The EKC hypothesis postulates that there is a positive relationship between economic growth and environmental degradation as the country is developing, which means that a country is willing to sacrifice their environment in order to raise their standards of living from initial low levels. Yet, the hypothesis assumes that a country will prioritize their environmental quality after achieving successful development. Therefore, the EKC hypothesis has an inverted U-shaped curve when pollution indicators are plotted against income per capita (Dinda, 2004). By analyzing the data from 31 developing countries from 1970 to 2013, Aye & Edoja (2017) found a negative relationship between economic growth and carbon dioxide emissions in low regimes and a positive relationship in high regimes. The low regime refers to the levels of GDP per capita below 4,686 USD, where environmental degradation decreases with economic growth while vice versa in high regime with GDP per capita above 4,686 USD. In this case, the EKC hypothesis is not valid, and the results are supported by Aslanidis & Iranzo (2009) and Ahmed, Rehman, & Ozturk (2017), among others. Their results suggest that when a country is in its early stage of development, its service sector emits less carbon dioxide compared to its manufacturing sector. The rise in GDP of a country will tend to produce more carbon dioxide due to the expansion of the manufacturing industry. Also, a country will face an economic boom period while the GDP is increasing, so people with more income will increase their dependency on electrical appliances and transportation, leading to higher consumption of energy and higher pollution levels. Nowadays, China is the largest developing country and has a very high GDP, hence many studies have been done to investigate the relationship between economic growth and carbon dioxide emissions in China. Wang, Hao, & Yao (2017) used GDP as the threshold for the panel smooth transition regression (PSTR) model, and the results suggest that the influence of GDP on carbon dioxide emissions show the characteristic of coincident double thresholds. Additionally, a pull effect was exerted by GDP on carbon dioxide emissions while the GDP is gradually rising. However, the pull effect on carbon dioxide emissions becomes weaker as the GDP continues to rise or even exceeds the threshold parameter. This is consistent with the study by Aye & Edoja (2017). However, the result is different from others because the turning point at which carbon dioxide emissions start to decrease is not found when the GDP is high, as claimed by Aye & Edoja (2017).

Based on Monasterolo (2020), the financial systems could help achieve the global climate targets by aligning investments with sustainability. However, investors are largely exposed to carbon-intensive assets that could become stranded, thus delaying the low-carbon transition and bringing new sources of risk for financial stability, i.e., climate-related financial risks. Abbasi & Riaz (2016) indicated that there is a long-run and positive relationship between CO_2 emissions and financial development in Pakistan by using an augmented VAR model. Their findings revealed that financial development and trade openness do not help to reduce the environmental degradation effects and lead to further environmental destruction. Venmans, Ellis, & Nachtigall (2020) explored the World Bank's position in defining and stimulating international markets for carbon. Adopting the viewpoint of public preference, they argued that their participation can be viewed as an answer to the common objective of reputational and financial benefits. A booming, privately driven carbon market followed during this time, often competing with, rather than catalyzing, private activities. However, because transparency is limited in relation to its operations, thereby reducing reputational risk, these operations may not meet the quality standards, especially with regard to additionality, which is required for carbon markets to be an efficient mechanism for mitigating climate change. Sawyer (2020) discusses the essence of the new era of financialization, detailing the changes that are especially important to the environment emergency in the financial sector and its ties with the real sector. The relationship between financial sector growth ('financial development') and economic growth is reviewed, and the importance of recent empirical results for the financial sector's role in addressing climate emergencies is established. It is also argued that the policy response to climate emergencies and environmental degradation should be integrated into an industrial strategy. Xiong, Tu, & Ju (2017) investigated the regional differences in the effects of financial development on CO_2 emissions in China by using panel data. The study indicated that some parts of China that are well-developed could help to reduce emissions with more financial development. However, there is an inverse relationship in which financial development tends to increase the emissions of CO_2 in China in the areas that are less developed, and this situation further leads to harmful environmental degradation.

According to Yaw (2017), the state of the environment has gathered the attention of the world for more than a decade. Issues such as depletion of the ozone layer, the rise in global temperature and altered rainfall patterns are not new anymore; we now know that these issues began a long time ago and new information is being gathered continuously. The change in global climate is known as the world most conspicuous threat to children's health. What makes it worse is that no country is spared. All countries, regardless of whether they are high- or low-income countries, are experiencing the effects of climate change. The worst scenario of climate change would be future children inheriting an untenable world that lacks vital ecological resources to support them. However, the use of renewable energy is one of the ways to reduce the effects of climate change. Renewable energy, such as solar power, hydropower and biomass are commonly used in Malaysia. Malaysia is ASEAN's biggest user of solar power and is ranked sixth on the global list of top solar photovoltaics (PV) employers. It is one of the ASEAN countries to make it to the top ten alongside Vietnam (IRENA, 2019). According to IRENA (2019), the Philippines is known as ASEAN's largest employer of wind energy. One example to prove that renewable energy is indeed very helpful in reducing the effects of climate change is that Petroliam Nasional Berhad (Petronas) is considering investing in renewable energy on a commercial scale.

The study by Chen et al. (2019) regarding the relationship between renewable energy consumption and CO_2 emissions shows that there is a negative relationship between both variables. They found that, in the long run, the increasing use of renewable energy is able to reduce carbon emissions. The addition of the renewable energy variable is able to support the inverted U-shaped EKC hypothesis. The study by Cheng, Ren, Wang, & Yan (2019) shows similar results, that renewable energy is useful in reducing carbon emissions. Their study, which focuses on BRIICS countries (Brazil, Russia, India, Indonesia, China and South Africa), shows that renewable energy production in BRIICS had increased from 19.72 terawatt-hours (TWh) to 300.67 TWh. The drastic usage of renewable energy is able to reduce the effect of CO_2 emission. Additionally, Dong, Sun, & Hochman (2017) mentioned that renewable energy consumption is crucial to reducing carbon emissions, and their results also showed that renewable energy will have a significantly negative impact on CO_2 emissions. Moreover, based on Vikniswari et al. (2019a), the heavy reliance on non-renewable energy incurred scarcity and severe environmental destruction.

Demographic changes, such as size of population, urbanization and household structure, have positive impacts on carbon dioxide emissions (O'Neill et al., 2012). The authors also mentioned that the emission of carbon dioxide reacts proportionately to the changes of population size. Both ageing and urbanization also have significant relationships with carbon dioxide emissions but it is less proportional compared to population size. Cohen (2015) mentioned that an increase in population causes an increase in the production of plant and animal foods. The production of these foods has significant impacts on the atmospheric concentration of greenhouse gases, which include carbon dioxide, methane and nitrous oxide. However, population growth and carbon dioxide emissions do not have a long term equilibrium relationship (Knapp & Mookerjee, 1996). Based on their findings, carbon dioxide emissions and population lack cointegration, which means that population is not the sole factor in the cause of climate change. Sulaiman & Abdul-Rahim (2018) found that population growth does influence carbon dioxide in the short run but it does not have a great impact on climate change in the long run. They used the vector error correction model Granger causality approach to determine the causality relationship of population growth and carbon dioxide emissions in both the short run and the long run.

3. Methodology

In this study, CO_2 emissions will represent climate change, and the selected independent variables include financial development, foreign direct investment, economic growth, renewable energy consumption and population. Annual data from 2006 to 2015 were collected from five ASEAN countries—Malaysia, the Philippines, Vietnam, Indonesia and Thailand. The type of data applied in this study is panel data. The basic model below in Equation 1 was extracted from the research by Dietz & Rosa (1997) based on the Environmental Kuznets Theory (EKC).

$$CO2_{it} = \beta_0 + \beta_1 RE_{it} + \beta_2 EG_{it} + \beta_3 PO_{it} + \varepsilon_{it} \quad (1)$$

Where,
CO2 = Carbon dioxide emissions
RE = Renewable energy
EG = Economic growth
PO = Population
β_0 = Y-intercept
t = Year
ε_{it} = White noise error term.

Equation 1 has been extended by including financial development, as shown in Equation 2. The proxy for this variable is domestic credit to the private sector. The following model consists of four independent variables, which are population, renewable energy, economic growth and financial development.

$$CO2_{it} = \beta_0 + \beta_1 RE_{it} + \beta_2 EG_{it} + \beta_3 PO_{it} + \beta_4 FD_{it} + \varepsilon_{it} \quad (2)$$

Where,
CO2 = Carbon dioxide emissions
RE = Renewable energy
EG = Economic growth
PO = Population
FD = Financial development
B0 = Y-intercept
i = Malaysia, Thailand, Indonesia, Philippines, Vietnam
t = Year 2006, 2007, …, 2015
ε_{it} = White noise error term.

A panel unit root test will be used to conduct the preliminary analysis. This test shows the stationary conditions of the variables. Then, the Levin–Lin–Chu (LLC) test is used to check the stationarity of each variable. Last, but not least, the pooled ordinary least squares (POLS), fixed effects model (FEM) and random effects model (REM) are used for the estimation. A likelihood ratio test is conducted in order to choose between the POLS and REM. While for for comparison between REM and FEM, the Hausman test was used. Diagnostic checking will also be conducted to check for the existence of econometric problems.

3.1. Panel Unit Root Test

A unit root test is used to look for stationarity in the time series. Times series data is said to be stationary when there is a shift in time that does not lead to a change in the shape of distribution. One of the major factors contributing to non-stationarity is a unit root. If a times series contains a unit root, it tends to display a systematic pattern that is unpredictable. With panel unit root tests, the results can be used to determine whether a time series variable is non-stationary (random walk and unit root) or contains a unit root. In this test, the null hypothesis will be generally defined as a unit root being present in the time series variable, while the alternative hypothesis will be stationarity, explosive root or trend stationarity existing in time series variables. This depends on the type of unit root test being utilized in the study. There are different types of panel unit root tests: the Levin, Lin and Chu (LLC) test; the IM, Pesaran and Shin (IPS) test; the Breitung test, and the Hadri test to investigate the common unit root process, while the Fisher–PP and Fisher–ADF tests examine the individual unit root process. The non-stationarity of the variables needs to be verified to fulfil the classical linear regression model assumptions, which require constant variance in the econometric model. With constant variances, the ordinary least squares (OLS) method can be utilized to obtain accurate results so the estimators will be efficient, the hypothesis testing is valid, and t-statistics and p-values in the model will be reliable.

For this study, the Levin–Lin–Chu test was employed. According to Levin, Lin, & Chu (2002), this test is used to generalize the model that allows for the heterogeneity of individual deterministic effects and the heterogeneous serial correlation structure of error terms by assuming the same first order autoregressive coefficients. The power of this test is the probability of rejecting null when it is false and the null hypothesis is a unit root. The LLC test is based on the augmented Dickey–Fuller (ADF) regression model, as shown in Equation 3.

$$\Delta y_i = \alpha_{0i} + x_{0i} + x_{1i}t + \varepsilon_{it} \quad (3)$$

Where, $i = 1,2,\ldots\ldots, N$; $t = 1,2,\ldots,T$.
The hypothesis of the LLC test is calculated as follows:
H_0: $x_i = x = 0$ (each time series contains a unit root).
H_1: $x_i = x < 0$ (each time series is stationary).

Based on Equation 3, when an individual effect (x_{0i}) and a time trend ($x_{1i}t$) are incorporated, the parameter of the lagged dependent variable is restricted to homogeneity in every unit in the panel model. Thus, the deterministic components are a significant source of heterogeneity. Moreover, the LLC test assumption states that both i and t will move towards infinity but T will increase at a higher rate. The required condition of the LLC test is $\frac{\sqrt{NT}}{T} = 0$, and the sufficient conditions are $\frac{NT}{T} = 0$ and $\frac{NT}{T} = k.$ The sample size suggested in the panel unit root test ranges from 10 to 250. The unit root test is appropriate when T is large or small but N is large (Levin et al., 2002). If T is very small, the test is undersized and has low power. The LLC test also has another limitation as it is highly dependent on the assumption of independence across individuals. Hence, this test is not suitable to apply in a cross-sectional correlation.

3.2. Pooled Ordinary Least Squares (POLS)

The POLS estimation is simply an OLS technique that runs on panel data, which is the combination of time series data and individual data. All specific, individual effects are completely ignored, which leads to a violation of basic assumptions, such as the orthogonality of the error term. POLS consist of few assumptions. It can be assumed that the regression coefficient is the indifferences among countries while pooling all observations together. Second, the error term of the model is assumed to be normally distributed, which means that it is not correlated with the independent variables. Another assumption is that the error term must have a mean of zero with constant variance. Also, the independent variables are assumed to be fixed in repeated sampling in the model. The last assumption is that all the independent variables in the model are exogenous.

3.3. Fixed Effects Model (FEM)

The FEM is a statistical model where the parameters of the model have fixed or non-random quantities. The term 'fixed effects' refers to the different intercepts across the subjects, yet each of the interceptions do not change their characteristics over time and they are not correlated with the characteristics of other individuals. It is known to be time invariant. The error terms and constants of each unique individual must not be correlated with each other, otherwise the fixed effect will be considered as inappropriate. Referring to Mushtaq & Siddiqui (2017), the effect of variables that fluctuate occasionally can be studied through the FEM. In order to use the FEM, it needs to fulfil the assumptions of the classical linear regression model. However, there are some side effects of using the FEM. Its usage will eliminate a lot of degrees of freedom and will result in unstable estimation results, and it cannot be used to determine the time-invariance caused by the dependent variable in the model (Torres-Reyna, 2007).

3.4. Random Effects Model (REM)

The REM is also known as the error component model and it has become the most common method for synthesizing a set of effect sizes. It allows a model to have its own fixed interception value. This model assumes that the intercept value is randomly drawn from the population. In this research, the REM assumes that all the variables are time-invariant. Furthermore, REM is normally used for the estimation of dummy variables, such as gender, preference and age, by using the least squares dummy variable model. The REM is able to detect the difference in true effect size. The individual effect is assumed to have no correlation with any regressor and estimates the error variance specific to a group. This is why the REM is more efficient than the FEM if the assumption holds.

3.5. Likelihood Ratio (LR) Test

The likelihood ratio (LR) test was first introduced by Neyman and Pearson in 1928. Lehmann (2006) stated that this test can be used to compare the maximum likelihood by using hypothesis testing. This test is also used to assess the goodness of fit of two statistical models – the POLS and FEM models. It can also be used when the test statistics of the estimated model are larger than the critical values of the model. Therefore, the POLS is preferable if the null hypothesis is not rejected, and vice versa.

3.6. Hausman Specification Test

The Hausman specification test (also known as the Durbin–Wu–Hausman test) is applied to investigate and detect endogenous regressors in a regression model. Sometimes, the predictor variables, referred to as independent variables, are determined by other variables in the system to calculate their values. According to one of the assumptions of the ordinary least squares (OLS) method, there must be no correlation between an endogenous regressor and the error term (Hausman, 1978). When a model contains endogenous regressors, it will cause the hypothesis testing to be invalid and the t-statistics and p-values will be unreliable, thus providing spurious and misleading results. In this test, the null hypothesis will be that the REM is better than the FEM, while the alternative hypothesis will be that the FEM is better than the REM. The decision rule for this test will be to reject the null hypothesis when the probability value of the Hausman test is less than the significance level, otherwise, do not reject the null hypothesis. The general formula applied in the Hausman specification test is shown below:

$$H = (\hat{\beta}FEM - \hat{\beta}REM)\ [(\hat{\beta}FEM) - Var\ (\hat{\beta}REM)]\ -1\ (\hat{\beta}FEM - \hat{\beta}FEM)$$

3.7. Diagnostic Checking

There are a few important tests to be carried out to verify the specification of this study's model, including a normality test, a variance inflation factor test, the Breusch–Godfrey serial correlation LM test, and the Breusch–Pagan–Godfrey test.

4. Results

4.1. Panel Unit Root Test

The analysis starts by conducting a panel unit root test for all variables using the Levin–Lin–Chu test. Rejection of null hypothesis indicates that the variable is non-stationary. Table 1 summarizes the outcome of the test at level for all variables.

Table 1. Levin–Lin–Chu test results.

Variable	Individual effects, level form	Individual effects, individual linear trends, level form
$LNCO_2$	-4.32587*** (0.0000***)	-0.47591 (0.3171)
LNFD	-1.39951* (0.0808*)	-6.11484*** (0.0000***)
LNGDP	-4.56744*** (0.0000***)	-1.16224 (0.1226)
LNPOP	-6.48760*** (0.0000***)	-8.65327*** (0.0000***)
LNRE	-1.57471* (0.0577*)	-1.38442* (0.0831*)

Note: The asterisks, * and ***, indicate rejection of null hypothesis at the 10% and 1% levels of significance, respectively.

This study employs a panel data model estimation to estimate the individual and time series effects for every variable, including the dependent variable, carbon dioxide emissions and the four independent variables (population, renewable energy consumption, GDP and financial development). The panel data estimation models employed are the pooled ordinary least squares model, the fixed effects model and the random effects model in order to identify the significant variables related to climate change.

Table 2. Panel data estimation.

Variable	POLS	FEM	REM
C	3.865291*** (0.342253)	1.724597*** (0.315924)	8.257759*** (0.409223)
LNFD	0.083682*** (0.026831)	0.232376*** (0.049677)	-0.128164*** (0.020650)
LNPOP	-0.503724*** (0.030668)	1.078312*** (0.249804)	-0128164*** (0.029968)
LNGDP	0.498562*** (0.025629)	0.203110*** (0.033711)	0.188024*** (0.029373)
LNRE	0.232258*** (0.014188)	0.638006*** (0.072915)	0.291502*** (0.007901)
R-squared Adjusted R-squared	0.988400 0.987369	0.997869 0.997454	0.997372 0.996424

Note: ***, indicates rejection of null hypothesis at the 1% levels of significance.

Table 2 depicts the results for the POLS, REM and FEM estimations. The POLS R-squared is 0.9884, which means that 98.84% of the total variation in carbon emissions is explained by the total variation in the independent variables. From the results, all of the explanatory variables are significant at the 1% level of significance. Table 2 contains the results for the FEM model estimation, and we can see that the R-squared for Model 2 is 0.9979, which means that 99.79% of the total variation in CO2 emissions can be explained by the total variation in the explanatory variables. The independent variables (financial development, population, GDP and renewable energy consumption) are all significant at the 1% significance level. Thus, all of the explanatory variables are significant at the 0.01% significance level (the standard errors are in parentheses).

4.2. Model Comparison

Table 3 depicts the results of the likelihood ratio test and the Hausman test. By referring to the likelihood ratio test results, the null hypothesis was rejected at 1%, 5% and 10% because it has a probability of 0.0000, which is less than 0.01, 0.05 and 0.1. Hence, the fixed effects model is preferable compared to the pooled OLS model. After conducting the Hausman test, the result showed a probability of 0.0000, which indicates that the null hypothesis will be rejected. This is because the probability of 0.0000 is less than the 1%, 5% and 10% significance levels. Therefore, the fixed effects model is also preferable compared to the random effects model.

Then, a comparison between the expected sign of each independent variable in this study and the actual sign from the FEM result was conducted. First, the actual sign from the result shows that there is a positive sign between the relationship of financial development and climate change, which is in line with the expected sign in this research. This means that financial development increases the carbon emissions in the ASEAN countries and contributes to climate change. This finding is also supported by previous studies (Abbasi & Riaz, 2016; Boutabba, 2014; Sadorsky, 2010), which concluded that financial development has a significant and positive impact on CO2 emissions. When a country has better developed financial systems and institutions, it can help to attract overseas investors, which will improve a country's financial and economic development. However, industrialization will cater for the heavy production of goods and services. This will lead to environmental degradation and more carbon will be emitted due to intense use of fossil fuels and waste produced from factories, which will further contribute to the causes of climate change.

The relationship between population and carbon emissions is positive and significant, indicated by the results of the FEM. It follows the expectation of this study in which population has a positive impact towards carbon emission. This relationship is supported by the majority of the previous studies in which it was concluded that size of population will lead to an increase in the level of carbon emissions. According to Stephenson, Newman, & Mayhew (2010), rapid growth in population will deplete more key resources, such as water and fossil fuels. This means that there will be higher consumption of, and demand for, natural resources, and may cause the mismanagement of energy resources. Demographic changes, such as size of population and urbanization, have positive impacts on CO2 emissions as the emissions react proportionately to the changes in population size (O'Neill et al., 2012).

GDP was also found to have a significant and positive relationship with climate change in this study. This finding is aligned with the expectation that there is a positive relationship between CO2 emissions and GDP. This is due to the fact that a highly productive country often has greater economic growth activities, which becomes one of the factors of rapid industrialization. In particular, when a country has greater economic development, it also has a greater level of industrialization, which increases the level of carbon emissions contributing to climate change.

Moreover, renewable energy consumption was discovered to have a positive relationship with carbon emissions. However, this finding contradicts the expected sign in this study, that renewable energy consumption should have a negative impact on carbon emissions. This means that renewable energy does not contribute to the reduction of carbon emissions. Insufficient financial incentives provided by governments is also one of the reasons for the slow development of renewable energy technology (Apergis, 2010). It is quite difficult for ASEAN countries to fund R&D development for renewable energy as they are still developing.

Table 3. Model comparison.

	LR Test	Hausman Test
Test Statistic	84.728593***	35.632729***
Decision Making	Null hypothesis is rejected	Null hypothesis is rejected
Conclusion	FEM is more appropriate compared to POLS	FEM is more appropriate compared to REM

Note: ***, indicates rejection of null hypothesis at the 1% levels of significance.

4.3. Diagnostic Checking

4.3.1. Detection of Multicollinearity

Multicollinearity problems happen when more than one explanatory variable is found to have high correlation within the regression model. The symptoms of multicollinearity are high standard errors, low significance levels, and extremely high R2 values.

Table 4. Covariance matrix.

Variable	LNFD	LNPOP	LNGDP	LNRE	VIF
LNFD	0.0007	0.0002	0.0002	0.0001	2.0718
LNPOP	0.0002	0.0009	0.0006	-0.0002	3.2298
LNGDP	0.0002	0.0006	0.0007	-0.0002	2.9151
LNRE	0.0001	-0.0002	-0.0002	0.0002	2.8282

The covariance matrix results in Table 4 depicts that there is no strong correlation between the independent variables. Also, the variance inflation factor (VIF) shows that there is no serious multicollinearity problem because the VIF values for all of the variables are less than ten for all three models. As there is no serious multicollinearity problem, the variables are verified and can be used to conduct the regression analysis.

4.3.2. Normality, Heteroscedasticity and Autocorrelation

Table 5 displays the outcomes of the serial correlation, heteroscedasticity and normality distribution tests. First, the Lagrange multiplier (LM) test is used to prove whether a model is serial correlated by determining its p-value. The result shows that the model is free from autocorrelation problems because the p-values of the chi-square distribution for these models are greater than the 1% significance level. Hence, the null hypothesis is not rejected and there is no autocorrelation. This proves that they are consistent and unbiased. The outcome of the Breusch–Pagan–Godfrey test shows that the probability of 0.1825 is greater than the 1%, 5%, and 10% levels of significance. Thus, the null hypothesis is not rejected, and this indicates that the model is free from heteroscedasticity problems (homoscedasticity). The result of the normality test (0.3923) is higher than the 1%, 5% and 10% levels of significance, which shows that the error term of the model is normally distributed. In short, the model is free from diagnostic problems.

Table 5. Diagnostic checking results.

Model	
Diagnostic Checking:	
LM Test	23.5956*** (0.0146)
Breusch–Pagan–Godfrey Test	6.2322* (0.1825)
Normality Test	1.8716*** (0.3923)

Notes: The p-values are written in parentheses; * and *** denote rejection at the 10% and 1% significance levels, respectively.

5. Conclusion

Overall, the main objective was to examine the significant factors that contribute to climate change in selected ASEAN countries from 2006 to 2015. As such, the pooled ordinary least squares (POLS) method was applied, along with unit root, Hausman, likelihood ratio and diagnostic checking tests. By employing panel data analysis, it was found that the fixed effects model (FEM) is preferable, and the results show that all independent variables, including financial development, are found to have a significant and positive effect on climate change. However, renewable energy consumption is found to be inconsistent with the expected sign. According to Adams & Nsiah (2019), this might be due to the intermittent nature of its output and inadequate storage technology for renewable energy, which is in line with the context of developing ASEAN countries.

In order to prevent the damaging effect of financial development on the environment, governments in ASEAN countries should develop financial markets by allocating and using the funds for projects which will introduce low-carbon and clean energy technologies. This should increase the motivation of firms to lower their carbon emissions. For instance, local governments should direct their central bank to monitor the allocation of financial resources of each bank. Then, the banks should monitor the enterprises after financial resources are allocated to ensure that credit is not being used at the cost of environmental quality. If an enterprise is involved in any activity that contributes to environmental degradation, the authorities should penalize those who default by placing slightly higher interest rates on loans and issuing fines as punishments. Additionally, the governments should also motivate the banking sector to invest in businesses that utilize renewable energy with the purpose of achieving a sustainable environment. In particular, the banking industry should allocate financial resources to R&D for developing new energy efficient technologies. The banking sector could also use part of the financial resources to buy patents for these technologies in order to earn a profit as part of their income while working toward reducing environmental degradation.

The adoption of renewable energy solutions that work with energy efficiency strategies will help to reduce carbon emissions by over 90% (IRENA, 2019). According to Irena, the power systems generated by renewable energy can function more efficiently while supporting sustained economic growth. There are many forms of renewable energy, such as bioenergy, hydropower, and geothermal, ocean, solar and wind energy. Ultimately, the electricity sector needs to be totally decarbonized for the energy transition, which can be achieved by making good use of renewable energy, increasing energy efficiency and adjusting power systems to be more flexible. The industrial sector is one of the largest carbon emitters, but the attention given to policies is not enough. Steps should be taken by the government, such as offering financial incentives (i.e., grants, tax credits) and setting renewable portfolio standards (i.e., setting a renewable heat quota), among others. Indeed, by increasing the production and consumption of renewable energy, the manufacturing sector will play a crucial role in decarbonization. In conjunction with energy management, wind and solar technology can be easily implemented and together constitute a distributed energy resource application.

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