AN ANALYSIS ON THE FACTORS THAT FACILITATE RENEWABLE ENERGY CONSUMPTION IN ASEAN-5 COUNTRIES

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ABSTRACT

The aim of this study is to empirically shed light on the impacts of oil price and Trade Openness (TO) on renewable energy consumption across ASEAN-5 countries. This article incorporated annual time series data from 1997 to 2020 and employed panel data estimation analysis. All variables, including GDP, CO_2, oil price, and TO are showing a significant impact on renewable energy consumption. Model Fixed Effect Model (FEM) was adopted for analysis after evaluating the Pooled Ordinary Least Squares (POLS) and Random Effect Model (REM) using the Hausman Test. Thus, the results revealed that the improvement in trade openness and oil price could generate renewable energy consumption for ASEAN-5 economies. Finally, the study has recommended a few policies to control the trade openness and oil price in promoting the use of renewable energy sources in ASEAN countries.

Keywords: *trade openness, renewable energy consumption, CO_2 emissions, oil price, ASEAN*

INTRODUCTION

Over past decades, non-renewable energy that will run out in future has become a worldwide concern. Most of the non-renewable energy is a fossil fuel, which includes natural gas, coal and petroleum. These energies are non-sustainable and are the main contributor that cause global warming and climate change. To protect the next generation, switching non-renewable energy to renewable energy is a significant action that must be taken immediately. Examples of renewable energy are wind, solar, hydro energy and clean energy, which can mitigate climate change [1]. Before the popularisation of renewable energy, non-renewable energy like natural gas, coal and petroleum was widely used in commercial, residential and transportation. The heavy usage of non-renewable energy caused the scarcity of the sources and serious environmental problems. To solve the problems, renewable energy was introduced as an option to fulfil energy demand meanwhile minimise the environmental problem. However, the overall percentage of renewable energy consumption in ASEAN-5 countries showed a decreasing trend from 1997 to 2016 [1]. Several factors affect renewable energy consumption in ASEAN-5 countries, such as economic growth, CO_2 emission, real oil price and trade openness. In this study, we would like to investigate the significant impact of these factors on renewable energy consumption in ASEAN-5 countries.

Among the five ASEAN countries Malaysia's population is low and its rich vast lands have facilitated this country's move to renewable energies compared with other neighbour countries [2]. The total electricity capacity in Malaysia is 13 GW [3], 84% of which is generated in thermal power plants and 16% in hydropower plants [4]. Besides, Malaysia also produces solar energy. In addition, Malaysia produces a high level of palm oil, producing abundant biomass energy is possible; Malaysia can produce. However, the statistic showed that from 1995 to 2007 the total produced renewable energy has decreased from 7% to 5% [2]. The energy consumption available in the Philippines is 16% electricity generated from hydropower since the country rich in freshwater resources. Besides , 19% from renewable energies [4]. They also generate electricity from solar power and technically 7404 MW of electricity from wind power [5].

Moreover, the Philippines can commercially produce 20 MW of biomass-sourced electricity. In Thailand, hydropower generated 8% of electricity for consumption. Besides, only 4% of electricity is generated from renewable sources. Besides, Thailand also a country rich in solar energy, the potential for solar radiation in this country is 5.1 kWh/m^2/day [4]. Thailand also produced electricity from wind energy for consumption [6]. In addition, compared to the neighbour countries like Indonesia and the Philippines, this country is rich in geothermal energy. The consumption of renewable energy in Thailand from 2003–2007 has increased by 2% [2]. However, renewable energy consumption from 1995 to 2207 dropped from 30% to 20% in the Philippines. 10% of Indonesia's energy is produced from hydropower sources, 27% from renewable sources, and the rest from thermal power plants [2]. The country also produced wind power of 3–6 m/s.

Besides, Indonesia also has the ability to produce biomass energy and geothermal energy [7]. Singapore only has a major demand for thermal energy and hydropower; geothermal energy is not produced in this country. However, this country has little investment in solar energy, where the electricity produced from

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solar panels is only about 90 kWp [4] and limited biomass energy is produced from wood waste [2] .

During the Great Recession in 2008, most ASEAN countries suffered a great recession in their economic growth, especially Malaysia and Philippines. For example, Malaysia has undergone a serious downturn in history and cause a decrease in the domestic economy by around 6% [8]. GDP per capita had decreased by around 13%, whereas renewable energy consumption had decreased by around 10%. Besides, the GDP per capita of the Philippines decreased by around 4% and renewable energy consumption dropped from 31.72% to 31.22% [9]. Low GDP per capita had led to low productivity in the production of renewable energy. Low renewable energy production reduced the demandfor consumption of renewable energy. For the past decade, the ASEAN-5 countries presented rapid growth in carbon dioxide (CO_2) emissions Chu [10] the carbon dioxide emission per capita will reach 12.1 tons per year in Malaysia. This has also affected the renewable energy consumption in ASEAN countries.

Indonesia is looming in the opposite direction based on the rules of the Paris climate accords for 2020 [11] . The Indonesian government intends to set up over 100 coal-fired power plants, which will drag to more carbon-rich tropical forests deforestation in Indonesia. In addition, there is an extension of car-centric transportation base installation among the Indonesians. Based on these two situations, CO_2 emissionss will grow rapidly in Indonesia as deforestation and transportation will release a high amount of CO_2 emissions to the country. According to Coca [11],, Indonesia has tremendous renewable capacity with solar, hydro, wind, and geothermal resources in the country. However, due to the very little investment in the renewables sector, and only 2% of that renewable capacity has been utilised in Indonesia. This shows that the Indonesian government does not take advantage of their natural resources to control the high CO_2 emission in the country.

Furthermore, there is also a rapid decrease in the trade openness of Malaysia. Trade openness can boost the economic growth of a country by importing and exporting renewable energy sources. With the high technology of renewable energy, it can improve environmental quality and increase renewable energy consumptions. When the export volume of renewable energy in Malaysia increase renewable energy consumption will also be increased. This will also increase renewable energy production in the country and export/ deliver more exported goods to other countries. Malaysia is one of the largest Photovoltaic (PV) makers globally and has exported to other countries [10]. If all the Peninsular Malaysia are fitted with solar panels, Malaysia can generate 1.4 times more electricity compared with the electricity generated by fossil fuel burning. Then, more solar can be exported to foreign country, the more renewable energy consumption. Thus, less solar panel installation in Malaysia is one of the issues that cause low consumption of renewable energy.

Besides, Vietnam's power supply is reported to be running out soon due to many Vietnam's power projects are left behind the schedule. Although Vietnam has a large scale of hydropower sources, mostly the large and medium-sized hydropower sources have been adopted, just left a few small-sized hydropower sources only for exploitation [12]. Hydropower will constitute 12.4% only of all electricity supply in Vietnam 2030, which will cause the supply to be shortage sooner. Therefore, Vietnam is planning to import more annual electricity from China and Laos in the following years, which are expected to rise to 3000 megawatts by 2025 and 5000 megawatts by 2030. The increment in importing electricity has significantly contributed to the trade deficit, which will indirectly affect renewable energy consumption. When Vietnam consumes more imported electricity, the renewable energy consumption in Vietnam will decrease. For Indonesia, the oil outputs have been diminishing gradually in size due to ageing well in recent years, making the country a net oil importer [13]. The main issue of Indonesia is that they rely more on fossil fuel and due to the oil output issue, the country has imported more fossil fuels from other countries. The increase in the country's import of fossil fuel had significantly contributed to the trade deficit, which indirectly affects renewable energy consumption. The more consumption of non-renewable energy, the lesser the renewable energy consumption.

During the Asian Financial crisis that occurred in 1997, the real oil price decreased dramatically [14]. The crisis started in Thailand due to the weakening of the Thai Baht. This crisis affected most Asia countries. The same goes with the Asian Financial Crisis, which affected countries such Malaysia, Indonesia, and the Philippines. Malaysia is a net exporter of oil, and other countries are mostly dependent on oil imports. The currencies and the price of the assets of these countries were declining and the debt of the countries were increasing during that period. Due to the economic slowdown in those countries, the oil demand decreased and affected the price of the oil during that period. The price had fall to as low as $8 per barrel during 1998. When the demand for oil decreases, this causes the demand for renewable energy increases. Due to the shortening of oil revenue, this scenario led to the Russian Financial crisis, which also occurred in 1998. The oil price was then increased to the highest level in November 2000. Another issue regarding the real oil price is the oil price shock that occurred during 2014. During the year 2014, the price of real oil price fell dramatically.

The oil price had fallen from $112 per barrel in June 2014 to $48 per barrel in January 2015 [15]. This has affected those countries involved in the import and export of oils. This caused the purchasing power to increase and production cost and inflation would be lowered if the real oil price dropped [16]. For example, the major oil importer, Indonesia, regenerate the expensive fuel subsidy programme to lower the oil prices. Other oil importers countries such as Thailand, also get the biggest heir of the low oil price because the countries are mostly dependent on road transport. The low oil prices caused the country to have more funds to invest in other projects, such as renewable energy which can bring growth and protect the environment of the countries. Since Malaysia, one of the major oil exporters will hurt badly compared to other oil importers when the oil price is low. Therefore, the only way is that government should focus on other industries.

Therefore, the aim of this study is to empirically shed light on the impacts of Trade Openness (TO) and oil price on renewable energy consumption across ASEAN-5 countries from the year 1997 to the year 2020. This study employed a variety of estimate techniques, including Model Fixed Effect Model (FEM), Pooled Ordinary Least Squares (POLS), and Random Effect Model (REM), to get more reliable results.

LITERATURE REVIEW

For the past two decades, non-renewable energy has been playing an important role in the daily life of people and there were number of research that focused on non-renewable energy. However, some researchers have also studied renewable energy consumption in these few years. A few researchers studied the effect of financial development on renewable energy consumption [17]-[18]. On the other hand, Akar [19] studied the impact of oil rent and natural gas rent on renewable energy consumption in Balkans countries. From the result of dynamic panel data analysis, the researcher has found that there is no relationship between oil rents and a positive and significant relationship between natural gas rent and renewable energy consumption.

Carbon dioxide (CO_2), or other term as greenhouse gas (GHG), is a form of gas which absorb and a diffuse radiation of thermal, and also maintains a suitable temperature for the Mother Earth [20]. Certain empirical studies show that CO_2 is one of the determinants that will affect renewable energy consumption. There was a positive relationship between CO_2 and renewable energy consumption [21]-[29]. Besides, there was a positive relationship between carbon dioxide emission and renewable energy consumption in the central region of China from 1996 to 2013 [23]. Lahiani [24] found out that there was a positive relationship between CO_2 emission and renewable energy consumption in G7 countries by using the data from World Bank's World Development Indicator for the year 1995 to 2014.

On the other hand, no relationship and a significant effect was found between CO2 emission and renewable energy consumption [19]. The researcher used Generalised Method of Moments (GMM) to prove this relationship. The researcher used the data from The World Bank's World Development Indicators. All the data was adapted from 1998 to 2011. Carbon dioxide emission did not show a significant relationship with renewable energy consumption in the western region of China from 1996 to 2013 [23]. The research data was adapted from Intergovernmental Panel on Climate Change (IPCC), National Coordination Office on Climate Change and National Development and Reform Commission. The researcher used the method of the dynamic panel data model and system GMM estimator. Sebri & Ben-Salha [30] study on the causal relationship between economic growth, renewable energy consumption, trade openness and carbon dioxide emissions in the BRICS countries over 1971–2010 within a multivariate framework using the ARDL bounds testing approach cointegration and vector error correction model (VECM). The empirical evidence shows that there is a negative long-run relationship between renewable energy consumption, economic growth, trade openness and carbon dioxide emissions. A study by Bilgili et al. [31] on the dynamic impact of renewable energy consumption on CO_2 emissions by using a revisited Environmental Kuznets Curve approach employs a panel data set of 17 OECD countries from1977 to 2010 and launched panel FMOLS and panel DOLS estimations. This study reveals the EKC hypothesis for the panel and indicates that GDP per capita and GDP per capita squared have the impacts on CO_2 emissions positively and negatively, respectively, and that renewable energy consumption yields negative impact on CO_2 emissions. Another remark of this paper is that the validity of EKC does not depend on the income level of individual countries of the panel in which the EKC hypothesis holds. A study on the aforementioned issues in the framework of environmental Kuznets curve in the EU countries from 2000 to 2014 using a spatial dynamic panel data model [32]. The results showed that renewable energy consumption negatively affected CO_2 emissions, and the relationship between economic freedom and CO_2 emissions was U-shaped. Their finding also shows that CO_2 emissions of a country were positively correlated with those of its neighbours. Other than that, GDP per capita is also used as one factor affecting renewable energy consumption. GDP per capita is the country's GDP divided by the population [18],[21]-[23],[26]-[28],[33]-[34]. highlighted that GDP per capita has a positive relationship with renewable energy consumption. Sadorsky [22] found a positive relationship in the 18 emerging countries. The 1% increase in GDP per capita will increase 3.39% to 3.45% of renewable energy consumption from 1994 to 2003. The data for this research was from US Energy Information Administration. The method used in the research was the Ordinary Least Square (OLS) method. Besides, from the other research from Sadorsky, GDP per capita had a positive relationship with renewable energy consumption. When GDP per capita increases by 1%, renewable energy consumption will increase by 8.44% in G7 countries from 1980 to 2005. Furthermore, Omri & Ngugen [28] found that a 1% increase in GDP per capita will lead to a 0.2% increase in the consumption of renewable energy. The results are concistent with Alam & Murad [34], where GDP per capita and renewable energy consumption among 25 OCED countries proven as positively correlated.

However, Akar [19] found out that there was a negative relationship between GDP per capita and renewable energy consumption. According to Garba & Bellingham (2021), a study on the impact of solid cooking fuels on GDP per capita in developing countries by using 46 sub-Saharan Africa results reveal a negative causal relationship running from traditional fuels use (solid) to GDP per capita. On the other hand, re-examine the effect of renewable energy consumption on economic growth across 38 renewable-energy-consuming countries from 1990 to 2018 [21]. Based on this result, nine economies such as Belgium, Italy, Israel, Morocco, Portugal, Romania, South Africa, Thailand, and the United States, show no relationship between consumption of renewable energy and economic growth.

Trade openness refers to the outward or inward orientation of a given country's economy. Trade openness is indicated by the import and export share in Gross Domestic Products (GDP). Based on , Alam & Murad [34], Omri, Daly & Ngugen [27] and Akar [19], trade openness is determined to have a positive impact on renewable energy consumption. The relationship between trade openness and renewable energy consumption are positive and statistically significant results was obtained at 1% and 5%. In this study, the researcher investigated 64 countries over the period 1990-2011 by using the dynamic system-GMM panel. The data on trade openness is taken from the World Bank's World Development Indicators. A 1% increase in the trade openness increases the renewable energy consumption by around 0.25%. The findings stated that trade openness has a statistically significant impact on renewable energy consumption except for the high-income panel. Alam & Murad [34] was proved that there a positive relationship between trade openness with renewable energy consumption through the result of the autoregressive distributed lag approach, dynamic ordinary least squares and fully modified ordinary least squares [29], there was a positive relationship between trade openness and renewable energy consumption among 64 countries. The research data is adapted from World Bank Development Indicators from 1990 to 2011. Lastly, Akar [19] stated that trade openness was positive and significant at 5% level in Balkan countries from 1998-2011. The researcher had to use Generalised Method of Moments (GMM) to prove this relationship. Based on Vikniswari et al. [1], the long-run elasticities results revealed that GDP and trade openness have a significant negative impact on renewal energy consumption in Southeast Asian Nations-4 Countries by using FMOLS and DOLS estimation. This is due to a higher degree of openness to trade in selected ASEAN countries can reduce the demand for renewable energy as the dependency on pollutive energy is high due to the huge demand by their local industries to generate productivity. A study by Zeren & Akkus [37] on the relationship between renewable energy consumption and trade openness in top Emerging Countries of Bloomberg from 1980 to 2015. The long-run relationship between panels is examined with the Dumitrescu-Hurlin panel causality test, Westerlund panel cointegration test with multiple structural breaks and Pesaran CCE-MG cointegration estimator was used in this study. The study reveals that the use of non-renewable energy is one of the main reasons for the increase in trade openness and the increase in the use of renewable energy was founded to be an important factor in decreasing the trade openness for these Emerging Countries.

Crude oil refers to the liquid fuel source that is located underground [33]. The real crude oil prices are measured using the pump price of gasoline, which is the US Dollar per litre. Lahiani [25] and Omri & Nguyen [28] mentioned that there is positive relationship between the real oil price and renewable energy consumption. An increase in oil price will increase renewable energy consumption in the long run in the United Kingdom and France [25]. The researchers used the nonlinear autoregressive distributed lag (NARDL) model to get the result mentioned above.

Besides, when there is 1% increase in the real oil price, it will lead to an increase of around 0.01% in the consumption of renewable energy [27]. On the other hand also stated no relationship between real oil price and renewable energy consumption in high- and low-income countries. The research used the data for the year 1960 to 2011 and the research had completed by using the dynamic system-GMM panel model. The data for the 64 countries were all obtained from the British Petroleum Statistical Review of World Energy and the U.S. Energy Information Administration. According to Bamati & Roofi [38], based on the research on the development level and the impact of the technological factor on renewable energy production by using the GLS panel data estimation method by dividing the countries into Developing Countries and Developed Countries, the result revel that renewable energy production is significantly determined by high technology export in developed countries, while high technology export is not statistically significant in explaining the use of RE sources in developing countries. The oil price has the smallest impact on renewable energy production in both groups.

Besides, the decrease in oil price will increase the consumption of renewable energy in the long run in Italy [25]. The researchers used the nonlinear autoregressive distributed lag (NARDL) model in the research. The data used in the research were collected from the Federal Reserve Bank of St. Louis from1955 to 2014 for G7 countries. Besides that, Omri & Nguyen [28] mentioned that renewable energy consumption is affected negatively and significantly by oil prices in middle-income countries. According to the research, 1% increase in oil price will decrease the renewable energy consumption by around 0.34%. The research used the data for the year 1960 to 2011 and the research had completed by using the dynamic system-GMM panel model. Rafiq & Alam [39] also stated a negative relationship between the real oil price and renewable energy consumption in Brazil, China, India, Indonesia, Philippines and Turkey in the period from 1980 to 2006 by using the ARDL model. This has been supported by Sadorsky in his research on G7 countries from 1980 to 2005 [22].

In conclusion, a lack of studies explored the relationship between trade openness and oil price on renewable energy consumption, especially in ASEAN countries. Therefore, the main of the study is to examine the effects of trade openness and oil price on renewable energy consumption in ASEAN-5 from 1997 to 2020.

METHODOLOGY

The data for this study has been obtained from World Bank and IRENA databases. Based on Sadorsky , the basic model is formed with the functional form REC = f (GDP, CO_2, OP). The functional form can be expressed in the econometric model as Equation 1:

$$REC_{it} = \beta_{0_{it}} + \beta_1 GDP_{it} + \beta_2 CO2_{it} + \beta_3 OP_{it} + \varepsilon_{it} \tag{1}$$

where REC = Renewable Energy Consumption, measured in % of the final total energy consumption

GDP = Economic growth, measured in Gross Domestic Product per capita

CO_2 = Carbon Dioxide Emission, measured in metric tons per capita
OP = Oil Price, measured in US Dollar per litre

However, the model for this research has been extended by adding a trade openness variable. The functional form can be expressed in the econometric model as Equation 2:

$$REC_{it} = \beta_{0_{it}} + \beta_1 GDP_{it} + \beta_2 \log(CO2)_{it} + \beta_3 OP_{it} + \beta_4 \log(TO)_{it} + \varepsilon_{it} \quad (2)$$

where REC = Renewable Energy Consumption, measured in % of the final total energy consumption
GDP = Economic growth, measured in Gross Domestic Product per capita growth (%)
CO_2 = Carbon Dioxide Emission, measured in metric tons per capita
OP = Oil Price, measured in US Dollar per litre
TO = Trade Openness, measured in %

MODEL ESTIMATION

Panel Unit Root Test

Panel Unit Root Test has two major objectives for examining the models. The first objective, unit root test is known as a tool to examine the variables' stationary status in the model. The stationarity status is significant for a model due to the status may assure the model's validity whether the panels have unit roots or the panel are stationarity. If the model panel has unit roots, the standard deviation of the model will be shown invalid due to the t-distribution is not followed. The second objective is that the unit root test is used to ensure the accuracy of the model's result. The unit root test is always carried out before the model is formed [40]).

Panel unit roots test assumes that the data is always not dependent and unanimous distributed among individuals. Besides that, all the individuals in the panel are assumed to have the same autocorrelation of first-order partial, however, all other parameters are allowable to change with ease across individuals in the process of error [41].

The regression of the panel unit root test is as follows:

$$\Delta\gamma_{it} = \rho_i \gamma_{it-1} + z'_{it}\gamma + u_{it} \quad (3)$$

where i = 1, 2, 3, …, N (the individual)
t = 1, 2, 3, …, T (for each individual time series observations)
z_{it} = the deterministic component may be zero or one
u_{it} = the stationary process

The hypothesis of the panel unit root test is also shown as follows:

H_0 = The panels are contained with unit roots (The panels are non-stationary)
H_1 = The panels are not contained with unit roots (The panels are stationary)

The rule of decision for the panel unit root test is that do not reject the null hypothesis, if the probability is bigger than the alpha, of 0.05. Otherwise, the null hypothesis, should be rejected.

POOLED OLS

The Pooled Ordinary Least Square (OLS) model is also named as a time-invariant or time-constant model. This model shows the attributes for given observation are consistent over time. The interpretation of this model is easy and simple. The assumption for pooled OLS model is the intercept and coefficient values for each observation are consistent over time. This model is used when there is homogeneity or no uniqueness in characteristics between different observations along the time. This model must follow the Classical Linear Regression Model (CLRM) assumptions to get unbiased, efficient and constant values [42]. According to Croissant & Millo [43], when there is a missing value in an individual component, pooled OLS model is the most suitable and efficient estimator for intercept and slope (β). Although the assumption will usually be labelled pooling model, pooled OLS model had based on the properties of error and the suitable estimation method. The problem is that the pooled OLS model cannot differentiate the different observations in terms of effect and attributes over time. When heterogeneity occurs in the estimated model, the estimated value will become biased, inefficient and inconstant. To solve the problem of heterogeneity, Fixed Effect Model (FEM) or Random Effect Model (REM) were suggested.

FIXED EFFECT MODEL (FEM)

The Fixed Effect Model (FEM), also known as the Least Square Dummy Variable Model, is a regression model that takes into account different characteristics from different observations with dummy variables. There are three assumptions in this model: the intercept are different across the dummy variables, slope of independent variables are the same and the time-variant. The regression of FEM can be written as:

$$Y_{it} = \alpha_1 + \alpha_2 D_{2i} + \alpha_3 D_{3i} + \ldots + \alpha_5 D_{5i} + \beta_3 X_{it} + \varepsilon_{it} \quad (4)$$

where D_{2i} = 1 if country is Thailand
= 0 if otherwise
D_{3i} = 1 if country is Indonesia
= 0 if otherwise
D_{5i} = 1 if country is Malaysia
= 0 if otherwise
X_{ii} = factor that affect Renewable energy consumption (e.g.: Carbon dioxide emission, trade openness, oil price…)
t = 1997-2014

Through FEM, the effect of each dummy variable of different variables was captured. However, there are some limitations in FEM. First, FEM might cause serious multicollinearity. Second, if there are too many dummy variables in the model, it will lead to a loss of useful information due to reducing in the degree of freedom. Last but not least, FEM might not be able to identify the impact of sometime-invariant variables.

RANDOM EFFECT MODEL (REM)

The Random Effect Model (REM) is used to test the individual's characteristics for each observation in the sample based on random error terms. While the random error term captures different characteristics from different observations and is not affected by time. Differ from FEM, and REM is not included dummy variable. In this model, the potential omitted variable is grouped and becomes an independent variable. REM assumes that the independent variables are uncorrelated with the cross-sectional error component [44]. By using REM, the number of unknown parameters will be reduced. Besides that, there is a lower probability of serious multicollinearity problems happening in the model due to reducing of independent variables. The sample equation of REM is as below:

$$Y_{it} = \beta_{1i} + \beta_2 X_{it} + u_{it} \quad (5)$$

$$Y_{it} = (\beta_{1i} + \varepsilon_i) + \beta_2 X_{it} + u_{it} \quad (6)$$

$$Y_{it} = \beta_1 + \beta_2 X_{it} + \varepsilon_i + u_{it} \quad (7)$$

where β_1 = Intercept's mean
β_1 = Independent variables' slope
X_{it} = Independent variable
ε_i = cross-sectional error component
u_{it} = Combination of cross-sectional and time series error component

Stephanie [45] stated that the Hausman Test, also known as the Hausman specification test, is used to detect endogenous regressors (predictor variables) in a panel model. Sometimes, the Hausman test is described as a test for model misspecification. It is used to determine whether fixed or random-effects model should be used. The accuracy of the Hausman test is a critical issue in panel data analysis. The null hypothesis (H_0) is that the preferred model is random effects, while the alternate hypothesis (H_1) is the model is fixed effects. The hypothesis testing is shown below:

H_0: The Random Effect Model (REM) is preferable.
H_1: The Fixed Effect Model (FEM) is preferable.

This test is to determine whether there is a correlation between the unique errors and the regressors in the model. The H_0 shows that there is no correlation between the two. If there is no correlation between the regressors and effects, the FEM and REM are both consistent, however, FEM is inefficient compared to REM.

The decision rule showed when the probability value (p-value) of H-statistics is lower than the significance level (0.1/0.05/0.01), the H_0 will be rejected. Otherwise, do not reject H_0. If H_0 is rejected, the REM is not suitable to use and FEM is preferable.

Breusch-Pagan Lagrange Multiplier (LM) test statistics is most well-known as cross-section dependence diagnostic and sometimes also known as Breusch-Pagan-Godfrey Test [45]. It tested for random effects in a linear model based on pooled OLS residuals. This test is designed to test random effects depending on the value of the chi-squared. If the null hypothesis is not rejected, the pooled regression model is appropriate. The null hypothesis (H_0) is the error variances are all equal Var $[u_t] = 0$, while the alternate hypothesis (H_1) is the error variances are not equal Var $[u_t] \neq 0$. The hypothesis testing is shown below:

H_0: Variances of error are constant Var $[u_t] = 0$.
H_1: Variances of error are not constant Var $[u_t] \neq 0$.

Firstly, estimate the model $Y = \beta_0 + \beta_1 X_1 + \ldots + \beta_k \beta X_k + u$, then we compute a $\sigma^2 = \frac{\sum u_i^2}{n}$ and $P_i = \frac{u_i^2}{\sigma^2}$. In order to test the hypothesis, we need to estimate an auxiliary model in which P and X must be linearity correlated, $P = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \ldots + \beta_k \beta X_k + v$. Chi-squared critical value, $X^2 \alpha,\ k$.

The decision rule showed when the probability value (p-value) is lower than the Chi-squared critical value, the H_0 will be rejected. Reject the H_0 when the Chi-squared is high. Otherwise, do not reject H_0. If H_0 is being rejected, the REM is preferable compared to pooled OLS estimation.

However, if compared pooled ordinary least squares (POLS) and the panel fixed effect model (FEM), with the used of F-statistic, reject H_0 when the F-test value is greater than the probability. Thus, FEM is more preferable as compared to pooled OLS estimation.

DIAGNOSTIC TEST

Multicollinearity is a situation where two or more independent variables have a perfect linear relationship between each other in a multiple regression equation. The result will show large variances when there is multicollinearity in the model. When there are large variances, the confidence interval will become wider. Other than that, the coefficients might be poorly estimated, have signs that do not make sense and the standard errors for the coefficients might be inflated ("Multicollinearity", n.d.). Insufficient of data will cause the multicollinearity appears in the model too.

One of the methods to detect multicollinearity problem is the Variance Inflation Factor (VIF). VIF is a method which can analyse the correlation between the independent variables. The formula of VIF is as below:

$$VIF = \frac{1}{1 - R^2}$$

The R^2 stated in the formula is the coefficient of correlation between the 2 independent variables. VIF starts with the number 1 and has no upper limit. The VIF with the value of 1 indicates no correlation between the independent variables in the model. VIF with a value less than 10 means that there is a moderate correlation between the variables. The VIF's value that is greater than 10 and the R-squared value is more than means that the correlation between the independent variables in the model is critical. Therefore, it will affect the poor estimation of coefficients and the controversial p-values. Another way to detect the multicollinearity problem is the tolerance value (TOL). The formula of TOL is as below:

$$TOL = \frac{1}{VIF}$$

TOL is the inverse of VIF. When the value of TOL is near zero, it indicates that the independent variable is highly correlated with the rest of the independent variables and vice versa.

The multicollinearity problem can be solved by increasing the sample size. When the data increases, the intensity of collinearity can be lowered due to the decreasing of standard errors. Furthermore, the multicollinearity problem can be solved by using the ridge regression. Ridge regression can be used to analyse the multiple regression data that suffer from multicollinearity. Ridge regression does not require unbiased estimators and it adds just enough bias to make the estimates reasonably reliable approximations of true population values [45]). Last but not least, the multicollinearity problem can be solved by combining the time-series and cross-sectional data and using the information from prior research.

The Normality test is used to determine whether sample data has been drawn from a normally distributed population (within some tolerance) ("Normality Test", n.d.). The result is not reliable if the normality assumption is not valid. Jarque-Bera test (JB test) is used to detect the normality of the residual. It tests whether the residual is normally distributed or not.

Jarque–Bera Test (JB test) is usually used for large data sets because other normality tests are unreliable when n is large. A goodness-of-fit test of whether sample dates have the skewness and kurtosis are matching a normal distribution. The formula for the JB test is stated below:

$$JB = n\left[\frac{S^2}{6} + \frac{k^2}{24}\right]$$

The n stated in the formula is the sample size of the observations, whereas s is the skewness and k is the kurtosis. The null hypothesis (H_0) of the JB test is addresses as the error term is normally distributed and the alternative hypothesis (H_1) is addressed as the error term is not normally distributed. For the decision rule, the researchers have to state as reject the H_0 if the JB test statistics is greater than the critical value at the significant level of 1%, 5% or 10% otherwise, do not reject H_0. Then, check the p-value. After that, they decideto reject the H_0 if the p-value is less than the JB test statistic. The researchers must always check the p-value. A small p-value and a large chi-squared value meant that we could reject the H_0 that the data is normally distributed.

RESULTS

The panel unit root test is popular among empirical researchers with access to a panel data set. It is used to test stationarity. If the variable is not stationary, it will cause a pseudo regression problem which the result is pointless, although there are high significant t-ratios and high . A few types of panel unit root tests are currently supported in Eview, and Levin, Lin, and Chu (LLC) tests are being selected in our study. The null hypothesis for this test is panel variable contains a unit root, whereas the alternative hypothesis is panel variable does not contain a unit root (stationary). The decision rule for the LLC test is to reject the null hypothesis when the p-value is significant. Reject the null hypothesis so that the data (variable) is stationary and no unit root. The result in Table 1 shows that all variables are stationary at I (1).

PANEL DATA ESTIMATION

The Ordinary Least Squares (OLS) method was probably the most widely used method to estimate the parameters in a linear

Table 1 Panel Unit Root Test

		Levin, Lin & Chu t*	**Levin, Lin & Chu t***
Model	**Variables**	**Individual Intercept and Trend**	**Individual Intercept and Trend**
		Level	**1st difference**
Model 1	lnREC	-1.646	-5.72
		-0.049	0
	lnGDP	-7.009	-1.97
		0	-0.025
	$lnCO_2$	-2.246	-2.923
		-0.012	-0.002
	lnOP	0.073	-6.503
		-0.529	0
	lnTO	-1.118	-2.33
		-0.132	-0.01

Notes: The asterisks *, **, and *** implies that the rejection of the null hypothesis of non-stationary at 10%, 5%, and 1% significance level, respectively. REC is renewable energy consumption, GDP is a gross domestic product, CO_2 is carbon dioxide emissions, OP is oil price and TO is trade openness.

Table 2 Panel Data Estimation Result

Model 1			
	POLS	**FEM**	**REM**
C	4.218***	2.541***	3.235***
	(0.000)	(0.000)	(0.000)
lnGDP	497.055***	57.049	445.699***
	(-0.001)	(-0.386)	(0.000)
lnCO_2	-0.579***	-0.611***	-0.609***
	(0.000)	(0.000)	(0.000)
lnOP	0.615**	0.130**	0.575***
	(-0.01)	(-0.026)	(0.000)
lnTO	-0.293***	0.199**	-0.003***
	(0.000)	(-0.026)	(0.000)
R-squared	0.761	0.98	0.759
Adjusted R-squared	0.751	0.979	0.749
D-W test stat	0.167	1.03	0.159

Notes: The asterisks *, **, and *** implies that the rejection of the null hypothesis of non-stationary at 10%, 5%, and 1% significance level, respectively.

regression model. Panel data is selected throughout this study as it consists of a number of periods (time series data) for a few countries (cross-sectional data). Hence, Pooled Ordinary Least Squares (POLS) method can be used to estimate the parameters. Basically, pooled OLS estimation can be described as an OLS technique run on panel data assumes intercepts are constant across countries, slopes are constant across countries and time-invariant.

Based on Table 2, the POLS model shows that the R-square (R^2) of is 0.7614, or 76.14% of the variation in the dependent variable is explained by the variation in all independent variables. When R^2 equal to 1, it means a perfect fit. Hence, it indicates that this is model has high goodness of fit as it is quite close to perfect fit. The independent variables such as TO is significant at 10% significant level while CO_2 emissions, oil price and GDP growth are significant at all significant level.

FEM model has the greatest adjusted R-squared among the POLS model and REM model. The FEM model has the value of 0.979 in adjusted R-squared. One independent variable has remained statistically insignificant with a p-value of more than 0.05, which are GDP. On the other hand, CO_2, OP and TO are statistically significant with a p-value less than 0.05.

Based on the result of the REM model, the adjusted R squared of 0.759 is lower than FEM and POLS model. The GDP, CO_2, OP and TO are statistically significant with a p-value less than 0.05.

Based on Table 3, the test statistic of the LR test is 240.431 and significant with a p-value of 0.000. Hence, FEM is preferable compared to POLS. In the LM test, the test statistic is 485.142 and significant with a p-value of 0.000. From the result, we can conclude that REM is preferable compared to POLS. We have performed the Hausman test to test on most preferable between FEM and REM. From the result of the Hausman test, the test statistic is 964.057 and

Table 3 Model Comparison Result

	LR Test	**LM Test**	**Hausman Test**
Test Statistic	240.4309***	485.142***	964.057***
	(0.000)	(0.000)	(0.000)
Decision Making	Reject null hypothesis	Reject null hypothesis	Reject null hypothesis
Conclusion	FEM is preferable compared to POLS	REM is preferable compared to POLS	FEM is preferable compared to REM

Notes: The asterisks *, **, and *** implies that the rejection of the null hypothesis at 10%, 5%, and 1% significance level, respectively

significant with a p-value of 0.000. As a result, we have sufficient evidence to conclude that FEM is better than REM. In conclusion, FEM was the best model for panel data for renewable energy consumption.

Overall, based on the FEM model, the real sign for OP was positive, which is consistent with the theory. The positive relationship between OP and REC was consistent with finding from [29],[38],[46]-[47]. An increase in oil price will lead to a decrease in consumption and a switch to renewable energy. The result corroboratesthat a 1% rise in the real oil price leads to a 0.58 per cent increase in renewable energy consumption. Meanwhile, CO_2 have a negative relationship with renewable energy consumption consistent [19],[25],[30]-[32]. Based on the estimation, 1% increase in CO_2, decreases renewable energy consumption by 0.61%. Whereas GDP positively correlates with renewable energy consumption was consistent [29] . When GDP per capita increases by 1%, renewable energy consumption will increase by 4.45% in ASEAN-5 countries from 1997 to 2020. Similarly, TO also have a negative relationship with renewable energy consumption. A 1% increase in the trade openness decreases the renewable energy consumption by around 0.003%. According to Vikniswari et al. [1], this is due to a higher degree of openness to trade in selected ASEAN nations, which can diminish demand for renewable energy because their reliance on pollutive energy is strong due to the large scale need for productivity by their local businesses [1]. This has been supported by [40]. An increase in those variables will lead to a decline in the consumption of renewable energy. Finally, GDP has been found to be insignificant for renewable energy consumption. This is aligned with [21]. This could happen most in ASEAN-5 countries due to a lack of technological innovation capacity in the economy and cause the high cost of managing renewable energy.

CONCLUSION

This research is studying the impact of economic growth, CO_2 emission, trade openness and oil price on renewable energy consumption among the countries of ASEAN-5, which are Malaysia, Thailand, Indonesia, Philippines, and Vietnam, from 1997–2014. Panel data analysis and diagnostic tests were conducted to find the relationship between independent and dependent variables and the model's strength. All variables are stationary for the panel unit root test at I(1). Besides, all variables, namely GDP, CO_2, oil price and

TO, show a significant impact on renewable energy consumption in ASEAN countries.

Trade policy is the law is relevant to the exchange of goods or services involved in international trade, including taxes, subsidies, and import or export regulations (Business Dictionary, 2019). Trade policy is also known as a commercial policy. This policy directly influences the movement of trading goods and services. There are several types of trade policy, including national trade policy, bilateral trade policy and international trade policy. By applying the trade policy, the production and the consumption between countries have no restrictions. Trade policy has an important character in the economic conditions, but trade alone cannot address all of the socio-economic and political challenges that influence economics. For instance, in Malaysia, one of the ASEAN countries and one of the world's most open economies, trade is equal to 130% of the GDP (export.gov, n.d.). The trade policy of Malaysia is tolerant and translucent. The trade policy has contributed 5% to the economic growth over the past few years. The trade policy impacts renewable energy consumption indirectly in an indirect way. When the government has tightened the trade policy, the economic growth will increase, the income of the public will increase; thus, the usage of renewable energy consumption will increase. Suppose the other ASEAN countries apply the trade policy too. In that case, the countries' economic growth will increase too, whichwill lead to an increase in the usage of renewable energy.

The study found a positive relationship between the oil price and renewable energy consumption. Hence, an indirect tax such as value-added tax or sale tax is to be charged on fossil fuel consumption by the government of ASEAN 5 to encourage the consumer to consume more renewable energy. On the hand, the revenue from the tax on fossil fuels can be utilising subsidies for the price of renewable energy, which also encourages the consumption of renewable energy that is relatively cheaper. Among the ASEAN 5, Malaysia is the only country that still provides subsidies for fossil fuel consumption. Therefore, the Malaysian government must take the initiative in reducing the subsidies on petrol and transfer the subsidies to the consumption as well as the production of renewable energy.

Moreover, the study also found that carbon emission has a negative relationship with renewable energy consumption. Hence, the government of ASEAN 5 may consider implementing the carbon tax or the cap and trade policy that can reduce the carbon emission effectively and use the revenue from the tax to subsidise the renewable energy consumption. By 2020, Malaysia, Thailand and Philippines have already implemented the carbon tax on their factories, while Indonesia and Vietnam will be implemented soon. Governments can also allocate more funds from the tax collected into organising more roadshows to increase awareness of the long-term benefit of consuming renewable energy.

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