EMPIRICAL ANALYSIS OF RENEWABLE ENERGY CONSUMPTION (REC) IN ASEAN-5

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DECLARATION

We hereby declare that:

(1) This undergraduate FYP is the end result of our own work and that due acknowledgement has been given in the references to ALL sources of information be they printed, electronic, or personal.

(2) No portion of this FYP has been submitted in support of any application for any other degree or qualification of this or any other university, or other institutes of learning.

(3) Equal contribution has been made by each group member in completing the FYP.

(4) The word count of this research report is 13347 words.

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DEDICATION

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LIST OF ABBREVIATIONS

LM	Breusch-Pagan Lagrange Multiplier Test
BP Statistical Review of WE	British Petroleum Statistical Review of World Energy
CO2	Carbon Dioxide
CDE	Carbon Dioxide Emission
DM	Decision Making
FEM	Fixed Effect Model
GDPPC	GDP Per Capita
IPCC	Intergovernmental Panel on Climate Change
JB test	Jarque-Bera test
NCO	National Coordination Office
NDRC	National Development and Reform Commission
NRE	Non-Renewable Energy
OP	Oil Price
PURT	Panel Unit Root Test
POLS	Pooled Ordinary Least Square
REM	Random Effect Model
RE	Renewable Energy
REC	Renewable Energy Consumption
TO	Trade Openness
TS	Test Statistic

EIA	U.S. Energy Information Administration
VIF	Variance Inflation Factor
WDI	World Development Indicators

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CHAPTER 1: OVERVIEW

1.0 Introduction

This chapter had explained the background, issues, questions, and objectives of this research. This chapter also discussed the significant of variables that contributed to this research.

1.1 Research Background

Over past decades, non-renewable energy that will run out in future has become worldwide concern. Most of the non-renewable energy is fossil fuel, which include natural gas, coal and petroleum. These energies are non-sustainable and is the main contributor that caused global warming and climate change due to CO2 emission from burning of fossil fuel. To protect the next generation, switching of non-renewable energy to renewable energy is the significant action that must be taken immediately. Renewable energy, such as wind, solar and hydro energy is sustainable and clean energy which can mitigate climate change.

Renewable energy development and consumption have become a trend among ASEAN-5 countries (Malaysia, Philippines, Indonesia, Vietnam and Thailand) due to rapid growth in urbanization for past three decades. ASEAN countries are blessed with diverse renewable energy. For example, Indonesia, Philippines, Vietnam and Thailand are richly with coal, oil and natural gas, while Malaysia is richly in petroleum. However, a small number of ASEAN countries are rely on the import of fossil fuel. For instance, Philippines and Thailand also rely on import of energy even they have produced their own energy. However, the supply of energy is unable to fulfil the demand for their country. To fulfil the demand, import of fossil fuel is needed for ASEAN countries. The import of fossil fuel was bought the concern of the risk of supply shortage and price fluctuation.

As ASEAN-5 countries has noticed that non-renewable energy has bring various adverse effects that mentioned above, ASEAN-5 countries are encouraged to put effort in development and consumption in RE. Based on ASEAN Plan of Action on Science, Technology, and Innovation for 2016-2025 (2017), all ASEAN countries are agreed to meet target of 23% renewable energy by year 2025. To meet the target, members of ASEAN-5 countries had taken various actions in development and consumption for renewable energy. According to The Star (2019), Malaysia government has been implemented 80 initiatives that relate to energy, especially renewable energy and R&D. Other than initiatives such as improving Net Energy Metering (NEM) and Energy Efficiency (EE), there are also RM2 billion Large Scale Solar 3, which is a project that has the objective with increase electricity generation from REC (MAQO Group, 2019).

National Renewable Energy Programme (NREP) which clearly outlined the targets, strategies, planning and tools that help the country to achieve the goals that set in Renewable Energy Act of 2008 within timeframe of 2011 to 2030 was implementing in Philipines. The total awarded projects under Renewable Energy Law in Philippines in 2016 was 657 and these projects are mainly focus on hydropower and solar resources (Philippine Department of Energy Portal, 2016). In Indonesia, Electricity Supply Business Plan (RUPTL) 2018-2027 was issued to increase renewable energy output. In this plan, around USD 30 billion was invested for NRE and it was 32% from total power plant investment (PLN, 2018). According to Chen (2019), Thailand had implemented innovative blockchain technology which can minimize the transfer cost and ensure the transparency of the trading.

Based on this study, it concerns on the four variables which include economic growth, CO2 emission, oil price and trade openness as the determinants of REC in ASEAN-5 countries.

The independent variable, economic growth that has the proxy of GDP per capita which indicates the measurement for economy of a country explain with total population and also reflect the living standard of a country (Amadeo, 2019). Based on Shahbaz, Hye, Tiwari and Leitão (2013), when the economic growth rise, the usage of energy will increase and this will lead to the rapid grow of economy. For example, during year 2010 to year 2013, GDP per capita of Malaysia had increased, the REC also increased too. Based on Cho, Heo and Kim (2015), something affect decrease in economic growth rate, such as Gross Domestic Product (GDP) per capita may have negative influence to the renewable energy growth. Therefore, economic downturn may harm renewable energy growth, such as during the great recession 2008. As a result, GDP growth of Malaysia had decrease to 0.1% at fourth quarter compared with 5.9% at the first three quarter (Goh and Lim, 2010). In contrast, REC will raise as strengthen the policies to grow the economy. Since year 1995, economic of ASEAN-5 country had grew more than 4% annually, this had created increase twice in consumption of renewable energy. They also expected the demand of renewable energy will increase continuously with 4.7% per year (Thomas, 2019). The Southeast Asia Energy Outlook report showed that domestic manufacturing sector had opportunity to grow, such as solar manufacturing industry in Thailand had raised output of Photovoltaic for international markets. This will strengthen the economy of the country by consume more renewable energy (The ASEAN Post Team, 2018).

CO2 emission or in another term as greenhouse (GHG) gas, is a form of gas which absorbs and diffuses radiation of thermal, and also maintains a suitable temperature for the mother Earth (Ritchie and Roser, 2017). CO2 emission usually happens through the inflammation of non-renewable energy and the energy industry contributes 33% of the whole amount of CO2 emission in global. Based on the data, the overall trends for the CO2 emission in the ASEAN-5 is increasing either in a rapid or slow rate, while Malaysia has the highest number of CO2 emission followed by Thailand, Indonesia, Vietnam and Philippines. The Intergovernmental Panel on Climate Change in 2007 has published about the awareness of global warning with the main cause of the release of CO2 by all the countries (Sadorsky, 2009). Therefore, the people are seeking for solutions to reduce or maintain the CO2 emission. According to Chen (2018), there are more than 100 countries include the ASEAN-5 had signed the “Kyoto Protocol to the United Nations Framework Convention on Climate Change (Kyoto Protocol)”. The main objectives of the Kyoto Protocol are to control the emission of human emitted GHG gas which is also control the CO2 emission and to promote the renewable energy sources for every country. Therefore, the ASEAN-5 is active in implementing the carbon-mitigating projects in their country. For example, the Green Technology Application for the Development of Low Carbon Cities (GTALCC) project in Malaysia, Low Carbon City Pilot project in Thailand, Rehabilitation of Hydro Power Plants project in

Indonesia, Low Carbon Technology Catalogue in Vietnam and Quirino Forest Carbon Project (QFCP) in Philippines. The main purpose of these projects is used to increase the usage of renewable energy and to reduce the CO2 emission.

Trade openness or in another term as economic openness, is referring to a country or economy that gives the authority or right to have trading with another country or economy. The openness's degree is able to calculate with the actual size of registered imports and exports in a country's economy (Keman, 2013). Based on the data, the overall trends for the trade openness in the ASEAN-5 is increasing either in a rapid or slow rate. According to the data found, the country with highest number of trade openness falls to Thailand. Malaysia, Indonesia, Philippines and Vietnam have lower number of trade openness compare to Thailand. Since Malaysia produce a huge amount of palm oil, it can be used as an example. According to Ooi (2019), Malaysian Palm Oil Board's (MPOB) data shows that Malaysia had exported palm oil, which is a renewable energy source, amounted to RM65.41 billion in 2018. Palm oil plantation had covered 15% of the country and it produced significant amount of combustible waste such as biomass from empty fruit bunches and biogas from methane capture of oil palm, which all these leftover materials will be considered as the renewable energy sources for the country to generate electricity (Bayar, 2011). Indeed, Malaysia's export volume of renewable energy source (palm oil) able to stimulate the REC, which promotes more renewable energy and transports these traded good to foreign countries. Same goes to other ASEAN countries such as Thailand. According to Thailand's Alternative Energy (2014), from the plan, the Board of investment (BOI) administer inducements and services to investors in various sectors. For illustration, the import duties on machinery declines, for raw or essential material and exception from duty on raw or essential materials for the usage in production for export. This will increase the import and export in Thailand which will lead to the consumption and production of the renewable energy. Next, Vietnam makes 3.4 gigawatts from solar and wind power every year and exports them to Europe and United States. Vietnam has huge number of natural endowments which included 4 to 5 kilowatt-hours per square meter for solar and 3,000 kilometres of coastlines with constant winds in the range of 5.5 to 7.3 meters per second (Breu, Castellano, Frankel & Rogers, 2019). Moreover, Philippines continues to dominate production of coconut oil and trade it to foreign countries (IndexBox, 2019). Indonesia focuses in trading biodiesel, which the overall biodiesel exports were 173,542 kilolitres and the shipments mostly headed to European Union (EU) and China. The sources that ASEAN-5 trade to foreign countries are renewable energy sources and the consumption will have significant impact on their trade openness ("Indonesia 2019 biodiesel exports to rise", 2019).

According to Kimberly (2019), crude oil is referring to the liquid fuel source that located underground. Crude oil is basically obtained through drilling. Crude oil can be get when the people heat and compress the organic materials over a long time ("What is Crude Oil? A Detailed Explanation on this Essential Fossil Fuel", 2009). Since oil or oil products are considered to be the closest substitute for renewable energy for most of the countries, the real crude oil prices are included in this research (Rafiq & Alam, n.d.). The oil price is measured using the pump price of gasoline which in the unit of US Dollar per litre. Based on Sadorsky (2009), **oil price** has the negative impact towards the REC, which means that when there is an increasing in oil price, REC will decrease. Omri & Nguyen (2014) found the same results between the oil price and REC too. When the oil price increases by 1%, REC will decrease around 0.34% and vice versa. The negative relationship between oil price and REC is able to be explained on reasons. According to Foy, Sheppard & Raval (2020), the price of oil will decrease which due to the decrement in the demand of oil. This situation usually happens during economic downturn. Therefore, as the closest substitute of oil products, the demand of RE will increase and lead to the increment of REC. This due to the RE sources such as biofuels are still less costly compare to their competitors, the margin of RE is considerable nowadays (Anderson, 2015).

1.2 Problem Statement

Before the popularization of renewable energy, non- renewable energy such as natural gas, coal and petroleum were widely used in commercial, residential and transportation. The heavy used of non- renewable energy causes the scarcity of the sources and serious environmental problem was incurred. To solve the problems, renewable energy was introduced as an option to fulfil energy demand meanwhile minimized the environmental problem. However, according to The World Bank (n.d.), the overall percentage of REC in ASEAN-5 countries showed decreasing trend from 1991 to 2015. There are several factors that will affect REC in ASEAN-5 countries which are economic growth, CO2 emission, oil price and trade openness. In this research, we would like to determine the relationship between REC and the independent variables in ASEAN-5 countries.

During Great Recession 2008, the selected ASEAN countries had suffered a great recession in their economic growth, especially Malaysia and Philippines. For example, Malaysia had undergone the serious downturn in the history, and caused the decrease in domestic economy by around 6% (Bank Negara Malaysia, 2009). **GDP per capita** had decreased by around 13%, REC had decreased by around 10%. GDP per capita of Philippines had decreased around 4% and REC had drop from 31.72% to 31.22% (World Development Indicators, 2019). Low GDP per capita had led to low productivity in produce renewable energy. Low production of renewable energy, the demand of renewable energy will decrease.

For the past decade, the ASEAN-5 country had presented increment trends whether is rapid or slow growth in **CO2 emission**. According to the Star Online (2015), CO2 emission per capita will reached 12.1 tons per year in Malaysia. This is because the increase in urbanization will cause CO2 emission to be raised too, the Malaysians will move towards to a lifestyle of carbon-intensive. When the population is getting bigger, the demand of automobiles for citizens and factories for industries will be higher in addition CO2 emission will grow too. Therefore, the Malaysia government tried to put effort on reducing carbon emissions by carrying out the carbon-mitigating projects and applying the renewable energy initiatives. However, the regulation on the mitigation and adaptation is still weak, so REC in Malaysia is still low. REC in Malaysia was dropped by 3.41% in 2016, while CO2 emission in Malaysia was at the highest rate among the time period of 1992-2016.

According to Coca (2018), Indonesia is approaching in the opposite direction based on the rules to perform the Paris climate accords for 2020. The Indonesian government’s intention to set up over 100 of coal-fired power plants which will drag in 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, CO2 emission will grow rapidly in Indonesia as the deforestation and transportation will release high amount of CO2 emission. In the matter of fact, Coca (2018) also stated that Indonesia actually has tremendous renewable capacity with solar, hydro, wind and geothermal resources in the country. However, due to the very little investments in renewable sector, there are only 2% of that renewable capacity has been utilized in Indonesia. This shows that the Indonesia government does not take advantage of its natural resources to solve the high CO2 emission in the country.

Among the past five years, there is a rapid decrease in the **trade openness** of Malaysia. Trade openness enables to boost the economic growth of the country by importing and exporting the renewable energy sources. And, with the high-technology of renewable energy, it is able to improve the environmental quality and also increase REC. When the export volume of renewable energy in Malaysia increases, the REC will increase too. This will also increase the production of renewable energy in the country and export or deliver more exports goods to other countries. Malaysia is one of the largest Photovoltaic (PV) makers globally and has export to other country. Since Malaysia is one of the largest Photovoltaic (PV) makers globally and has export to other country, solar panel can be used as an example in this situation. According to Chu (2019), Malaysia can produce more electricity (1.4 times) than electricity generates by combusting fossil fuel if all the Peninsular Malaysia equipped with solar panels. Then, more solar can be exported to the foreign country, the more the consumption of renewable energy. Thus, less installation of solar panel in Malaysia is one of the issues that cause low REC.

According to Xinhuanet (2019), Vietnam’s power supply is reported that it is running out soon due to there is a lot of Vietnam power projects left behind the schedule. Although Vietnam has the large scale of hydropower sources, mostly the large and medium-sized hydropower sources have been adopted, just left a few small-sized hydropower sources for exploitation only. The hydropower will constitute for 12.4% only of all supply of electricity in Vietnam by year 2030, which causes the supply to be shortage soon. Therefore, Vietnam is planning to import more annual electricity from China and Laos in the following years which are expected to raise to 3000 megawatts by year 2025 and 5000 megawatt by year 2030.

The increment of importing electricity had significantly contributed to trade deficit, which will affect REC indirectly. When Vietnam consumes more on imported electricity, REC in Vietnam will decrease.

Indonesia, the oil outputs has been diminishing gradually in size due to ageing well and lacklustre new reserves in the recent years, then making the country become a net oil importer (Indonesia to boost use of RE, 2020). The main issue of Indonesia is they rely more on the fossil fuel and due to the oil output issue, the country has imported more fossil fuels from other country. The increase in the country's import of fossil fuel had significantly contributed to trade deficit, which indirectly affect the consumption of renewable energy. The more the country consumes on non-renewable energy, the lesser the REC.

During the Asian Financial crisis that occurred at year 1997, the **oil price** had been decreased dramatically (Olowe, 2010). The crisis was started in Thailand due to the weakening of Thai Baht. This crisis had affected the Asia countries afraid of the declining of economy. The Asian Financial Crisis had also affected the countries such as Malaysia, Indonesia, Philippines and so on. Malaysia is a net exporter of oil and other countries are mostly the dependent of oil import. 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 economic slowdown of the affected countries, the demand of the oil was decreasing and it affected the price of the oil during that period. The price had fell to as low as $8 per barrel during the end of 1998. When the demand of oil had decreased, it will then lead to the increasing of demand of renewable energy. Due to the shortening of oil revenue, it led to the Russian Financial crisis which also occurred at 1998. The oil price was then increased back to the highest level in November 2000.

Another issue of oil price is the oil price shock which occurred during the year of 2014. During the year 2014, the oil price fell dramatically. Hou, Jodie, Jane and Dirk (2015) said that the oil price had been fallen from $112 per barrel to $48 per barrel between the periods of June 2014 to January 2015. This had affected the countries which import and export oil. Foo (2015) mentioned that purchasing power will increase, industries' production cost and inflation will be lowered down and if the real oil price dropped. For example, the major oil importer, Indonesia, was enhanced from the lower oil prices by regenerating the expensive fuel subsidy programme. Other members of ASEAN-5 and oil importers such as Thailand will get the biggest heir of the low oil price due to the countries are mostly depend on the road transport. The low oil price caused the country to have more funds to invest in other projects such as renewable energy which can bring advantages to 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 government can take the chance to focus on the other industries.

1.3 Research Question

i. What are the factors affect REC in ASEAN-5 countries from year 1991 to year 2015?
ii. How does trade openness act as interaction term and overall affect REC in ASEAN-5 countries from year 1991 to year 2015?

1.4 Research Objective

i. To study the factors that affect REC in ASEAN-5 countries from year 1991 to 2015.
ii. To examine the effect of trade openness that acts as interaction term and overall affect REC in ASEAN-5 countries from year 1991 to year 2015.

1.5 Scope of Research

The research will be conducted based on ASEAN-5 countries from year 1991 to 2015. ASEAN-5 countries that consists of Malaysia, Thailand, Philippines, Vietnam and Indonesia. The dependent variable of the research is REC while the independent variables are CO_2 emission, oil price, trade openness and GDP per capita. The interaction term for the research is trade openness.

1.6 Significant of Study

There are continued strongly rely on fossil fuels (non- renewable energy), which can increase CO2 emission and raise the local air pollution rate, even though the consumption of renewable energy had successfully implemented all around the world. Rely on consumption of non- renewable energy (fossil fuels) will raise emission of carbon dioxide by 60%. If this problem cannot be solved immediately, health and pollution costs may increase to 225 billion US dollar annually when year 2025. To control this cost, ASEAN Centre for Energy decide to consume renewable energy, since this choice is more cost-effective in term of pure economic. In year 2015, ministers of ASEAN decide a goal of consume 23% of RE when year 2025. This target applied to increase the region's REC by a-two-and-half-fold compared with year 2014 (IRENA Quarterly, 2017). Besides, the increase of total population had increased the consumption on natural resources, such as fossil fuels. This had increased the depletion of fossil fuels, therefore the solution became the important issue to be discussed. United Nations Framework Convention on Climate Change (UNFCC) decided to consume renewable energy which are clean and environment friendly (Kamaruddin Abdullah, 2005).

Research framework become more comprehensive if the model had extended and adding interaction variable. Based on Lahiani, Sinha, and Muhammad Shahbaz, there have many researches discuss the relationship between REC, economic growth and CO2 emission. We found out adding more independent variable such as trade openness able to provide contribution to the model. Trade openness consider as gap variable because there has only few researches study it.

Trade openness as the interaction term in this research found that there is significant effect with renewable energy consumption. The greater the trade openness, increase in import and export, hence raise in use and production of renewable energy. To raise the usage of renewable energy, trade openness will be the suitable policy to control global warming (Omri and Nguyen, 2014). Based on Murshed (2018), trade openness policies are able to act as the complement of environment polices, which able to rise the usage of renewable energy while reduce the CO2 emission. Due to trade openness, export of renewable energy facility of a country to another country more convenient. Hence, able to influence the country which are using non-renewable energy. The export of facility able to switch the consumption of non-renewable energy to renewable energy.

Environmental Kuznets Curve (EKC) theory can help to justify the reason why we choose trade openness act as an interaction term in our study. Trade openness is the variable that can interact with the others three variables which are CO2 emissions, Economic growth and oil price then affect the consumption of renewable energy. In EKC theory, it explained the relationship between the environmental quality and the development of economic. It had an idea of market forces will first increase during the economy development, and then decrease the environmental quality (further explanations in Chapter 2). For instance, trade openness enables CO2 emissions to raise and reduce at the same time through economic growth and technological effect. At the time the economy grows to a certain period, people will start to concern the environmental quality and then start to consume the renewable energy. This showed that the increase in the trade openness will bring positive relationship to the economic growth and will increase the CO2 emission, and at last will increase the REC.

The contribution of REC are technological innovation and favourable government policies. Countries which are members of ASEAN had agreed to have a target for technological innovation that related to renewable energy, like floating solar panels for better solar power efficiency (Thomas, 2019). For example, to have a better performance for solar energy, Solar PV being produced. This technology will increase the implementation of solar thermal in ASEAN country ("Scoping Study on Intra-ASEAN Value Chain Cooperation and Trade…" , 2016). Besides, the establishment of RE100 in year 2014, which is a collaboration with more than 100 enterprises to reach the target of 100% of renewable energy. This able to attract consumer to increase the REC. This also will reduce the price of renewable energy, hence increase the consumption because cost had reduced. ASEAN will become potential place for renewable energy to develop with the huge potential in renewable energy (Thomas, 2019).

1.7 Chapter Summary

In the research background, it consists of the introduction of the dependent variable (REC) and independent variables (trade openness, oil price, CO2 emission and GDP per capita). It then continues with the problem statement that determines the issues of the variables in this research. Moreover, this chapter also includes the research question and research objective which help to have a better idea on the concern and aim of the research. Furthermore, this chapter also includes the scope of study and the significant of study. In scope of study, it includes the region and variables that involved in this research while in the significant of study discusses the contribution of the variables.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

In Chapter 2, the study discussed the literature review on the relationship between dependent variable (REC) and four independent variables, which are economic growth (GDP per capita), carbon dioxide emissions, oil price and also trade openness.

Relevant theoretical framework on the dependent variable and independent variables will be discussed and the relevant graph will be given. Moreover, it is given the research framework of our study. Besides, this chapter also will show the critical reviews from all the past researchers’ finding on all our independent variables. Discussing the relationship between each independent variable with the dependent variable.

2.1 Theoretical Review

2.1.1 The Environmental Kuznets Curve (EKC) Theory

The theoretical Environmental Kuznets Curve theory, which also known as EKC concept, is taken into consideration in our research of study. EKC concept is recognized by Grossman and Krueger in the early 1990s. The EKC theory is a kind of theory that explains the relationship between the quality of environmental and the development of economic. There are a few of views of the EKC concept. First view is that the greater the activity of economic, the harmful the environment will be, based on the statistics assumptions on the investments of technology and environmental. Next, there is another view that when the income increases, the requirement of improving the environmental quality will increase and the available resources for investment will increase too (Stern, 2004).

From the Figure 2.1, it showed us the inverted U-shaped EKC. The Y-axis of the graph is label as the level of environmental degradation while the X-axis is label as GDP per capita (economic growth). This EKC graph used the idea that when the economic development growth occurs, the environmental level will worsen at a certain point. When the economy continues to grow and reaches a certain point of GDP per capita, the money is then invested back to the environment. Then the relationship between the environment and the society getting improves and the ecosystem restored (Agarwal, 2020).

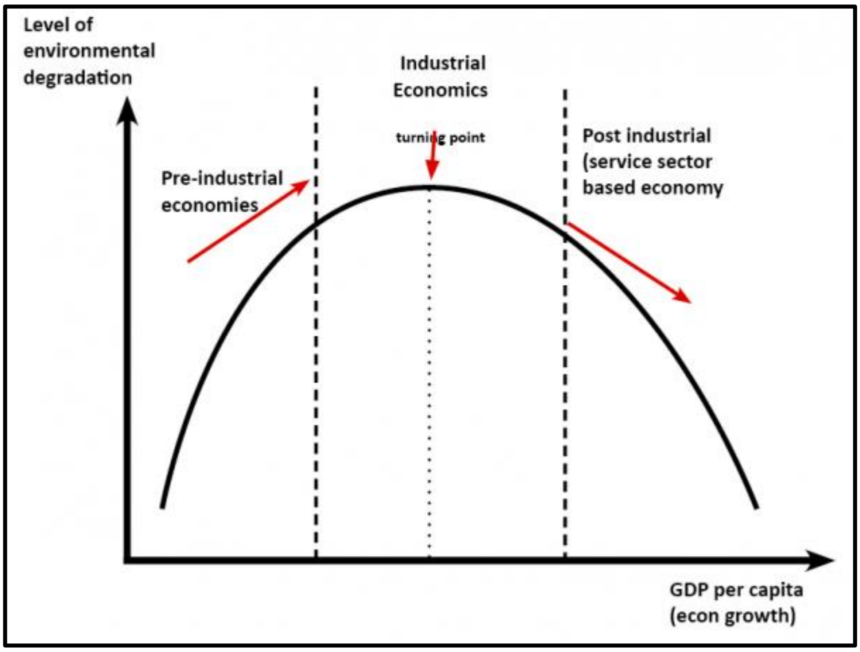
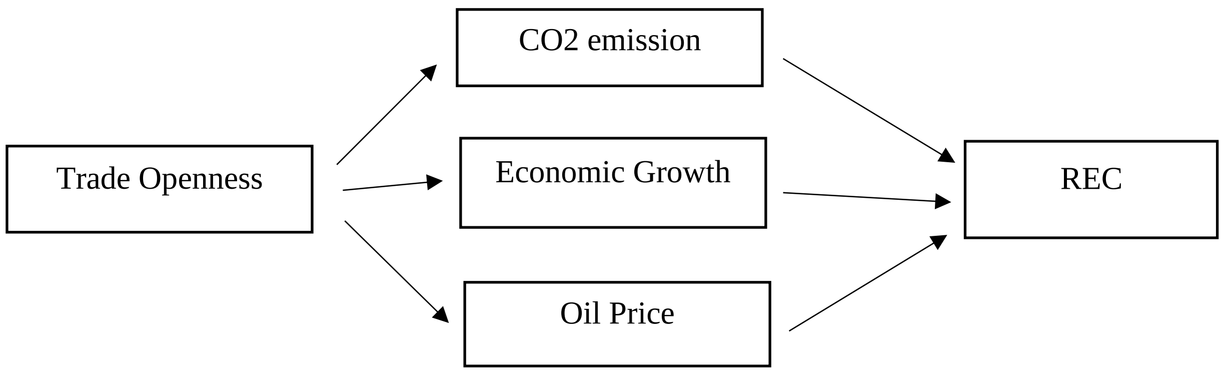


Figure 2.1

From the study by Yu, Nataliia, Yoo, & Hwang (2019), it said that trade is one of the important factors that helps economies to reduce CO2 emission and maintains economic growth simultaneously through the combination of scale, composition, and technique effects. The increase in export will increase the CO2 emission, however, the raise in import will lead to decrease in the CO2 emission. To makes possible to increase and decrease at the same time through economic growth. Sadeghieh (2016) support that GDP and CO2 emission will lead to higher REC in the countries. The study by Boufateh (2018) stated that CO2 emission will general raise during the beginning period of development before per capita income reaches in a propelled phase of development, a turning point from which the CO2 emission will in general fall. Moreover, in the study of Katircioglu (2017), it supports the interaction between GDP and environmental pollution. Besides, it also shows that changes in oil price significantly and negatively affect the EKC in such a dynamic economy. Zaghdoudi (2017) supports the view that when increase in oil prices will decreases in CO2 emission. This will indirectly affect the EKC phase of development. Boufateh (2018) also stated that in general, these early examinations concur on the significance of taking oil price in such a setting to the extent that the direction towards an expansion in the domestic cost of polluting energies could comprise an adequate measure adopted to decrease CO2 emission.

2.2 Research Framework



2.3 Empirical Review

2.3.1 REC

For past two decades, non-renewable energy is playing an important role in the daily life of people and there were numbers of researches that focus on non-renewable energy. However, there are also some researchers studied on REC in these few years. There are a few researchers studied on the effect of financial development on REC such as Anton & Nucu (2020) and Eren, Taspinar & Gokmenoglu (2019). Broad money (M2), domestic credit, and bank asset are the categories in financial development. There is positive effect between financial development and REC in European Union from 1990-2015 and India from 1971-2015 respective in this both papers.

Some researchers have examined the relationship between urbanization and REC. According to Salim & Shafiei (2014), there is no significant relationship between urbanization and REC in OCED countries from 1980 to 2011. The data was adapted from World Bank's World. Besides, Yang, Zhang & Zhang (2016) found out that the contribution of urbanization in RE was lesser than total energy consumption and proven by logarithmic mean Divisia index (LMDI) method. The data of this research were collected from Statistical Review of Word Energy 2013 for the year 1990-2012 in China. On the other hand, Askar (2016) was studied on the impact of oil rent and natural gas rent on REC in Balkans countries. From the result of dynamic panel data analysis, the researcher has found out that there is no relationship between oil rents and positive and significant relationship between natural gas rent and REC. The data was obtained from The World Bank's World Development Indicators (WDI) between the years of 1998-2011.

Based on Lin & Moubarak (2014), a positive relationship between labour and REC was found in China from 1977-2011. This relationship was proven by Autoregressive Distributed Lag approach (ARDL). Sadorsky (2009a) was studied on the relationship of electricity price and REC in 18 emerging countries from1994-2003. From the result of panel cointegration estimates there was a positive relationship of electricity price and REC. When there is 1% increase in real income per capita, consumption of renewable enegry per capita will increase by 3.5%. There is another paper from same author was found out there is positive relationship between electricity price and REC in G7 countries. The data was adapted from United Nations economic data base between years 1980-2005.

2.3.2 CO2 emission and REC

Carbon dioxide (CO2) or in another term as greenhouse gas (GHG), is a form of gas which absorb and diffuse radiation of thermal, and also maintaining a suitable temperature for the mother Earth (Ritchie and Roser, 2017). There are certain empirical studies shown that CO2 is one of the determinants that will affect REC. Sadorsky (2009), Chen (2018), Lin & Okonkwo (2016), Lahaini, Sinha & Muhammad Sbahbaz (2018), Lin & Moubarak (2014), Omri, Daly & Ngugen (2015), Omri & Nguyen (2014) and Salim & Rafiq (2012) mentioned that there was a **positive relationship** between CO2 and REC. Firstly, Sadorsky (2009) used error correction model (ECM) approach ordinary least squares (OLS) to estimate the CO2 effect on REC among G7 countries from year 1980 to 2005. The increase of CO2 emission will lead to the increase of REC. The data for CO2 was adapted from the U.S. Energy Information Administration (EIA). Besides, according to Chen (2018), there was a positive relationship between CO2 emission and REC in the central region of China from 1996 to 2013. The data of the research was adapted from Intergovernmental Panel on Climate Change (IPCC), National Coordination Office (NCO) on Climate Change and National Development and Reform Commission (NDRC). The method that the researcher used was dynamic panel data model and system GMM estimator. Lahaini, Sinha & Muhammad Sbahbaz (2018) found out that there was positive relationship between CO2 emission and REC in G7 countries except for Canada by using the data World Bank's World Development Indicator for the year 1995 to 2014. The methods used in the research were nonlinear autoregressive distributed lag (NARDL) model and autoregressive distributed lag (ARDL) model. Lin & Moubarak (2014) found out there is positive relationship between CO2 emission and REC in the China from 1977 to 2011. When CO2 increase by 1%, REC will increase by 0.75%. The data of research was adapted from China Energy Statistical Yearbooks. Based on Omri, Daly & Ngugen (2015), there was a positive relationship between CO2 emission and REC among 64 countries. The data of research is adapted from British Petroleum Statistical Review of World Energy (BP Statistical Review of WE) from 1990 to 2011. Besides that, Salim & Rafiq (2012) stated that CO2 is positive and significant at 1% level in Brazil, China, India, Indonesia, Philippines and Turkey from 1980 to 2006.

However, there is also negative relationship between CO2 emission and REC which mentioned by Sebri & Salha (2014). The research was studied the relationship between CO2 emission and REC from 1971-2010 in BRICS countries. The data was retrieved from World Development Indicators database of World Bank. On the other hand, Askar (2016) said that **no relationship** and significant effect was found between CO2 emission and REC. The researcher had used Generalized Method of Moments (GMM) to prove this relationship. The researcher had used the data from World Bank's WDI. All the data was adapted from 1998 to 2011. Chen (2018) also highlighted that CO2 emission did not show significant relationship on REC in western region of China from year 1996 to 2013. The data of the research was adapted from IPCC, NCO on Climate Change and NDRC. The method that the researcher used was dynamic panel data model and system GMM estimator.

2.3.3 Economic growth and REC

In this study, the proxy of economic growth used in our research is GDP per capita. GDP per capita is the country's GDP divided by the population (Kimberly, 2019). Sadorsky (2009), Eren, Taspinar & Gokmenoglu (2019), Chen (2018), Omri & Nguyen (2014), Md. Mahmudul Alam & Md. Wahid Murad (2020), Omri, Daly & Ngugen (2015), Lin and Moubarak (2014), Cho, Heo and Kim (2015) and Usama Al-mulali et al (2013) highlighted that GDP per capita has a **positive relationship** with REC. Sadorsky (2019) found the positive relationship in the 18 emerging countries. The 1% increase in GDP per capita will increase 3.39% to 3.45% of REC in the year 1994 to 2003. The data for this research was from EIA. The method used in the research was Ordinary Least Square (OLS) method. Besides, from the other research from Sadorsky (2009), GDP per capita had a positive relationship with REC. When GDP per capita increase by 1%, REC will increase by 8.44% in G7 countries in the year 1980 to 2005. The data of this research were all adapted from EIA. The researchers had used Error Correction model (ECM) and Ordinary Least Square (OLS) methods to prove this relationship. Furthermore, based on the research of Chen (2018), 1% increase in GDP per capita will lead to 1.907% increase in REC. The data of the research was adapted from IPCC, NCO on Climate Change and NDRC. The method that the researcher used was dynamic panel data model and system GMM estimator. The data was taken from the year 1996 to 2013. Omri & Nguyen (2014) said that 1% increase in GDPPC will lead to 0.2% increase in consumption of renewable energy. The researchers had used the data from the year 1990 to 2011 which adapted from BP Statistical Review of WE and WDI The method used in the research was panel unit root test and GMM estimator system. According to Md. Mahmudul Alam & Md. Wahid Murad (2020), GDP per capita and REC has a ppositive relationship among 25 OCED countries from the panel unit-root test. Based on Omri, Daly & Ngugen (2015), there was a positive relationship between GDP per capita and REC among 64 countries. The data of research is adapted from World Bank Development Indicators from 1990 to 2011. Lin & Moubarak (2014) found the positive relationship between GDP per capita and REC in the China from 1977 to 2011. The 1% increase in GDP per capita will lead to 0.61% increase in consumption of renewable energy. The data of research was adapted from China Energy Statistical Yearbooks.

However, Askar (2016) found out that there was a **negative relationship** between GDP per capita and REC. According to the result of system-GMM analysis from Askar (2016), GDP per capita has a negative and significant relationship with REC.

2.3.4 Trade openness and REC

Trade openness is referring to the outward or inward orientation (import, export and trade) of a given country's economy. Trade openness is indicated by the share of import and export in Gross Domestic Products (GDP). According to the research of Omri, & Nguyen (2014), Md. Mahmudul Alam & Md. Wahid Murad (2020), Omri, Daly& Ngugen, (2015), Askar (2016) and Sebri & Salha (2014), trade openness is determined to have a **positive impact** on the REC. There is positive and significantly results showed between trade openness and REC at the level of 1% and 5%. In this study, the researcher investigated 64 countries over the period 1990-2011 by using dynamic system-GMM panel. The data of trade openness is taken from the World Bank's WDI. When trade openness increases by 1%, REC increases by around 0.25%. The findings stated that except for the high-income panel, trade openness have a statistically significant impact on the REC. Md. Mahmudul Alam & Md. Wahid Murad (2020) was mentioned that there a positive relationship between trade openness with REC through the result of autoregressive distributed lag approach, dynamic ordinary least squares and fully modified ordinary least square. Based on Omri, Daly & Ngugen (2015), there was a positive relationship between trade openness and REC among 64 countries. The data of research is adapted from World Bank Development Indicators from 1990 to 2011. Askar (2016) was stated that the trade openness is positive and significant at 5% level in Balkan countries from 1998-2011. The researcher had use Generalized Method of Moments

(GMM) to prove this relationship. Lastly, Sebri & Salha (2014) was found out that there was a positive relationship between trade openness and REC among BRICS countries except South Africa from 1971-2010. This result is from FMOLS and DOLS by adapted data from World Development Indicators database of World Bank.

2.3.5 Oil price and REC

According to Kimberly (2019), crude oil is referring to the liquid fuel source that located underground. The oil price is measured using the pump price of gasoline which in the unit of US Dollar per litre. Lahiani & Muhammad Shahbaz (2018), and Omri, Daly & Ngugen (2015) proved that there is **positive relationship** between the real oil price and REC. According to Lahiani & Muhammad Shahbaz (2018), increase in oil price will increase the consumption of renewable energy in the long run in United Kingdom and France. The researchers had used the nonlinear autoregressive distributed lag (NARDL) model in the research ad get the result mentioned above. The data used in the research were collected from the Federal Reserve Bank of St. Louis for the year 1955 to 2014 for G7countries. Besides, Omri, Daly & Ngugen (2015) found out that when there is 1% increase in the real oil price, it will lead to an increase of around 0.01% in REC. The data of the research are adapted from BP Statistical Review of WE and World Bank Development Indicators. The research was focusing on the year from 1990 to 2011 by using the panel root test.

On the other hand, Lahiani, Sinha & Muhammad Shahbaz (2018), Omri & Nguyen (2014), Rafiq & Alam (n.d.), Salim & Rafiq (2012) and Sadorsky (2009) highlighted that there is a **negative relationship** between oil price and REC. According to Lahiani & Muhammad Shahbaz (2018), decrease in oil price will increase the REC in the long run in Italy. The researchers had used the nonlinear autoregressive distributed lag (NARDL) model in the research ad get the result mentioned above. The data used in the research were collected from the Federal Reserve Bank of St. Louis for the year 1955 to 2014 for G7 countries. Besides that, Omri & Nguyen (2014) mentioned that REC is affected negatively and significantly by oil price in the middle-income countries. According to the research, 1% increase in oil price will decrease the REC by around 0.34%. The research had 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 BP Statistical Review of WE and EIA. Rafiq & Alam (n.d.) also mentioned that there is negative relationship between the real oil price and REC in Brazil, China, India, Indonesia, Philippines and Turkey in the period from 1980 to 2006. The data for the research were obtained from BP Statistical Review of WE and EIA. The researchers had used ARDL model in the research. Sadorsky (2009) also found out that real oil price brings the negative impact the REC in the G7 countries in the year 1980 to 2005. The G7 countries involved Canada, France, Germany, Italy, Japan, United Kingdom, and United States. The data of the research are adapted from the EIA and BP Statistical Review of World Energy. The researcher had used the Panel cointegration estimates to get the result of the research.

On the other hand, Omri & Nguyen (2014) also stated that in low income and higher income countries show no relationship between real oil price and REC. The research had 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 BP Statistical Review of WE and EIA.

2.3.6 Trade openness as interaction term

Trade openness as an interaction term in this research is able to bring indirect effect to REC. Based on Sebri and Ben-Salha (2014), trade openness has a positive relationship with GDR per capita and REC. This indicates that international trade is bringing in technology for renewable energy while promoting the growth of economic. In this research, it had mentioned that there is positive relationship between CO2 and economic growth. This shows that the increase of development in economic will bring positive impact to trade openness and will increase CO2 emission.

2.4 Chapter Summary

In this chapter, the theory that can induced all the variables is EKC theory. There is a few studies in the past researches have proved that GDP per capita, CO2 emission, oil price and trade openness can be related with this theory. Based on the past research, all the variables showed either positive, negative or no relationship with the dependent variable. However, some of the variables showed all the three relationships or two relationships (positive and negative; positive and no relationship) according to different researchers in different studies.

CHAPTER 3: METHODOLOGY

3.0 Chapter Introduction

In this chapter, we will define and describe the variables, state the theoretical model and model estimation and discuss various tests that will be carried out.

3.1 Source of data

Variables	Unit Measurement	Source
1.REC	Percentage of final total energy consumption	The World Bank
2.CO2 emission	Metric Tons Per Capita	The World Bank and Our World In Data
4.Economic growth	GDP per capita growth, percentage	The World Bank
5.Trade openness	Current US Dollar	UNCTAD
6.Oil price	US Dollar per litre	The World Bank and Bloomberg

3.2 Data Description

Variables	Definition
1. REC	Renewable energy also known as clean energy (Lora, 2018). This type of energy is developing from the natural sources or processes that are constantly restored. Renewable energy includes wind, sunlight, geothermal heat, wind, tides, water and

	other forms of biomass (PennState Extension, 2009).
2.CO2 emission	Carbon dioxide (CO_2) or in another term as greenhouse gas (GHG), is a form of gas which absorb and diffuse radiation of thermal, and also maintaining a suitable temperature for the mother Earth (Ritchie and Roser,2017). Based on OECD (2005), CO_2 emission is the form from combustion of carbon and respiration of living organisms that colourless, fragrance-free and non-venomous gas. Furthermore, one of the independent variables of the research is urbanization.
3.Economic growth (GDP per capita)	GDP per capita is the country's GDP divided by the population (Kimberly, 2019).
4.Trade openness	Trade openness is one of the variables that will affect the dependent variable, REC. Trade openness is referring to the country's economy orientation on outward and inward aspect. Trade openness is indicated by the share of import and export in GDP.
5. Oil price	The real crude oil prices are measured using the pump price of gasoline which in the unit of US Dollar per litre.

3.3 Econometric Framework

3.3.1 Basic model

Based on Sadorsky (2009), the basic model is formed with the functional form REC= f (GDP, CDE, OP). The functional form can be expressed in the econometric model as stated below:

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

Where REC = REC, measured in % of final total energy consumption

GDP = Economic growth, measured in GDPPC

CDE = CO2 emission measured in metric tons per capita

OP = Oil price, measured in US Dollar per litre

3.3.2 Empirical model 1

The first model for this research will include trade openness variable into basic model. The functional form can be expressed in the econometric model as stated below:

$$REC_{it} = \beta_{0_{it}} + \beta_1 GDPPC_{it} + \beta_2 \log(CDE)_{it} + \beta_3 OP_{it} + \beta_4 \log(TO)_{it} + \varepsilon_{it}$$

Where REC = Renewable energy consumption, measured in % of final total energy consumption

GDPPC = Economic growth, measured in GDP per capita growth (%)

CDE = CO2 emission, measured in metric tons per capita

OP = Oil price, measured in US Dollar per litre

TO = Trade Openness, measured in US dollars at current prices in millions

3.3.3 Empirical model 2

The second model in this research include trade openness as interaction term to examine the joint relationship with other determinants to REC. The functional form can be explained as REC= f (GDPPC*log(TO), log(CDE*TO), OP*log(TO)). The econometric model as stated below:

$$REC_{it} = \beta_{0_{it}} + [\beta_1 GDPPC_{it} * \log(TO_{it})] + [\beta_2 log\ (CDE_{it} * TO_{it})] + [\beta_3 OP_{it} * \log(TO_{it})] + \varepsilon_{it}$$

where REC = REC, measured in % of final total energy consumption

GDPPC = Economic growth, measured in GDP per capita growth (%)

CDE = CO2 emission, measured in metric tons per capita

OP = Oil price, measured in US Dollar per litre

TO = Trade Openness, measured in US dollars at current prices in millions

GDPPC*log(TO), log(CDE*TO), OP*log(TO) = Interaction terms

3.4 Model Estimation

3.4.1 Panel Unit Root Test (PURT)

PURT has two major objectives for examining the models. First objective of this test is it has used as a tool to check 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 to make sure the accurateness of the model's result. PURT is always carried out before the model is formed (Mahadeva & Robinson, 2004).

The assumption of PURT is the data is always not dependent and unanimous distributed among individuals. Besides that, all the individuals in the panel are assuming 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 (Barbieri, 2009).

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

$$\Delta y_{it} = \rho_i y_{it-1} + z'_{it}\gamma + u_{it}$$

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 PURT t is also shown as following:

H_o = 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)

When the probability is bigger than alpha, α of 0.05, null hypothesis, H_0 should not be rejected. Otherwise, the null hypothesis, H_0 should be rejected.

3.4.2 Pooled Ordinary Least Square (POLS)

POLS model also named as time-invariant model because this model shows the attributes for specific observation are consistent across the time. The interpretation for this model is easy and simple. The assumption for POLS is the consistency of each observation’s intercept and coefficient values all the time. This model being used when there is homogeneity or no uniqueness in characteristics between different observations along the time. This model must follow assumptions of Classical Linear Regression Model (CLRM) to get unbiased, efficient and constant values (Gujarati & Porter, 2009). According to Croissant and Millo (2008), when there is missing value in individual component, POLS model is the most suitable and efficient estimator for intercept and slope (β). Although the assumption usually will be labelled pooling model, POLS model had based on the properties of error and the suitable estimation method. The problem is POLS model cannot differentiate the different observations in term of effect and attributes over the time period. When there is heterogeneity occurs in the estimated model, the estimated value will become biased, inefficient and inconstant. Fixed Effect Model (FEM) or Random Effect Model (REM) were suggested to apply to solve the problem of heterogenity.

3.4.3 Fixed Effect Model (FEM)

FEM also known as Least Square Dummy Variable Model which is a regression model that able to take into account of different characteristics from different observations with dummy variables. There are three assumption in this model which are the intercept are different across the dummy variables, slope of independent variables are same and time variant. The regression of FEM can be written as:

$$Y_{it} = \propto_1 + \propto_2 D_{2i} + \propto_3 D_{3i} + \cdots + \propto_5 D_{5i} + \beta_2 X_{it} + \varepsilon_{it}$$

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 Singapore

=0 if otherwise

X_{ii} = factor affect REC (eg: Carbon dioxide emission, urbanization and etc)

t = 1997-2016

Through FEM, the effect of each dummy variable of different variables is able to capture. However, there are some limitations in FEM. First, FEM might cause serious multicollinearity. Second, when there are large number of dummy variables in model, it will lead to loss of useful information due to reduce in degree of freedom. Last but not least, FEM might not able to identify impact of sometime-invariant variables.

3.4.4 Random Effect Model (REM)

REM is adapted to test each observation of sample on their characteristic based on random error term. While the random error term is to capture different characteristic from different observation and not affected by time. Differ from FEM, REM is not included dummy variable. In this model, the potential omitted variable is grouped and become an independent variable. REM is assuming that the independent variables are uncorrelated with the cross-sectional error component (Kenneth & Jennie, 2010). By using REM, the number of unknown parameters will be reduced. Besides that, there is lower probability of serious multicollinearity problem happen in model due to reduce of independent variables. The sample equation of REM is as below:

$$Y_{it} = \beta_{1i} + \beta_2 X_{it} + u_{it}$$

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

$$Y_{it} = \beta_1 + \beta_2 X_{it} + \varepsilon_i + u_{it}$$

Where β_1 = Intercept's mean

β_2 = Slope of Independent variables

X_{it} = Independent variable

ε_i = cross sectional error component

u_{it} = Cross sectional and time series error component's combination

3.4.5 Hausman Test

Stephanie (2017) stated that Hausman Test which also known as Hausman specification test is used in panel model to detect endogenous regressors (predictor variables). Hausman Test also stated as a test for model misspecification that used to determine whether FEM or REM should be used. The accuracy of the Hausman test is a critical issue in panel data analysis. The null hypothesis (H_0) is the preferred model is random effects while the alternate hypothesis (H_1) is the model is fixed effects. The hypothesis testing is shown as 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 as compared to REM. If there is a correlation, FEM is consistent and REM is inconsistent. Test statistic formula is stated as below:

$$H = (\beta_{FE} - \beta_{RE}) [Var (\beta_{FE}) - Var (\beta_{RE})]^{-1} - (\beta_{FE} - \beta_{RE})$$

The decision rule shows that 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 being rejected, which means the REM is not suitable to use and FEM is more preferable.

3.4.6 Breusch-Pagan Lagrange Multiplier Test (LM)

LM test statistics is well-known as cross section dependence diagnostic and sometimes it also known as Breusch-Pagan-Godfrey Test (Stephanie, 2016). It tested for random effects in a linear model based on POLS 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] ≠ 0. The hypothesis testing is shown as below:

H_0: Variances of error are constant Var[u_t] = 0.

H_1: Variances of error are not constant Var[u_t] ≠ 0.

Firstly, estimate the model $Y = \beta_0 + \beta_1 X_1 + \cdots + \beta_k \beta X_k + u$, 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 which P and X must 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 shows that 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, which means the REM is more preferable as compared to pooled OLS estimation.

However, if compare POLS and the panel 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.

3.4.7 Multicollinearity

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.

To detect multicollinearity problem, Variance Inflation Factor (VIF) was suggested to carry out. VIF is a method which can analyse the correlation between the independent variables. The formula of VIF is illustrated as below:

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

The R^2 that stated in the formula is the coefficient of correlation between the 2 independent variables. VIF is started with the number of 1 and it has no upper limit. There is no correlation between the independent variables when the value of VIF equivalent to 1. While there is a moderate correlation between the variables when VIF's value less than 10 means that. When the VIF's value that greater to 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 p-values are controversial. The other 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 to zero, it indicates that the independent variable is highly correlated with the rest of the independent variables and vice versa.

Multicollinearity problem can be solved by increasing the sample size. When the data increased, the intensity of collinearity can be lowered down due to the decreasing of standard errors. Furthermore, 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 to true population values (Stephanie, 2017). Last but not least, the multicollinearity problem can be solved by combining the time-series and cross-sectional data as well as used the information from prior research.

3.4.8 Normality test

This 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. The function of Jarque-Bera test (JB test) is to detect the normality of the residual which testing the residual is normally distributed or not.

Others normality test become unreliable when the sample size is large, thus JB test was used when there is a large data set. A goodness-of-fit test is defined by whether sample data have the skewness and kurtosis that are matching a normal distribution. The formula for JB test is mentioned as below:

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

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 JB test is addressing as the error term is normally distributed and the alternative hypothesis (H1) is addressing 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. Lastly, the make the decision of rejecting the H_0 if the p-value is less than the JB test statistic. The researchers must always check the p-value. This is because a small p-value and a large chi-squared value meant that we can reject the H_0 and means that the data is normally distributed.

3.5 Chapter summary

This paper had provided the basic model and extension model for dependent and independent variables. Next, we had discussed definition of variables and sources of getting data of variables. We also discussed various tests which are PURT, POLS, FEM, REM that will be carried out to examine the estimated model. In diagnostic checking, we had stated the definition of each test, method to detect and solution for multicollinearity problem. Multicollinearity problem can be detected by using VIF and TOL. The solution for multicollinearity problem is decrease the standard error through increase the sample size. Lastly, JB test had been used to test normality of residual for testing the normality of model.

CHAPTER 4: DATA ANALYSIS

4.0 Introduction

This chapter will discuss the result that ran for all test from Chapter 3, and compare the final result for both test in order to find out the suitable model.

4.1 Panel Unit Root Test (PURT)

Panel Unit Root Test is the usually way for researchers applied to examine for panel data. It is used to test for the its stationarity. If the variable is not stationary, it will cause pseudo regression problem which the result is pointless although there are high significant t-ratios and high R^2. In Eview, there are few types of Panel Unit Root Test currently supported, and Levin, Lin, and Chu (LLC) tests is being selected in our study. This test is carried out by using unit root on the level and include in test equation of individual intercept. The null hypothesis for this test is there is contain of unit root in panel variable whereas the alternative hypothesis is there is no unit root (stationary) contain in panel variable. The decision rule for LLC test is to reject null hypothesis when p-value is less than 1%,5% and 10% significant levels. Null hypothesis being rejected means that there is stationary and no unit root in the variable.

Result for model 1 in table 4.1 showed that all variables are significant at 1% in the level form except CDE which is significant at 5% in the level form. On the other side, model 2 (interaction terms model), showed that all interaction variables are significant at level 1% in the level form. In conclusion for this, the result showed in both models are stationary as they are all stationary at 1%, 5% or 10% significant level in the level form.

Table 4.1: Panel Unit Root Test

Model	**Variables**	Levin, Lin & Chu t* Individual Intercept and Trend Level
Model 1	REC	-5.25772*** (0.0000)
	GDPPC	-3.88038*** (0.0001)
	LOG (CDE)	-2.01963** (0.0217)
	OP	-2.86644*** (0.0021)
	LOG (TO)	-2.70755*** (0.0034)
Model 2	REC	-5.25772*** (0.0000)
	GDPPC*LOG(TO)	-4.12384*** (0.0000)
	LOG (CDE*TO)	-3.05921*** (0.0011)
	OP*LOG(TO)	-2.72846*** (0.0032)

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

4.2 Panel Data Models

4.2.1 Pooled OLS

The result of POLS model shows that the R-squared (R^2) of Model 1 is 0.796489 or known as 79.65% of the variation in 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 GDP is significant at 10% significant level while CDE, OP and TO is significant at all significant level.

Besides, the result of POLS of Model 2 in Table 4.3 shows that the R^2 is 0.68. It means that there is 68.00% of variable in dependent variable is explained by the variation in all the independent variables. TO multiply CDEs and TO multiply OP are significant at all significant level. TO multiply the GDPPC is insignificant at all significant level.

4.2.2 FEM

According to the FEM model's result in Table 4.2, FEM model has the greatest adjusted R-squared among the POLS model and REM model. The FEM model has the value of 0.963435 in adjusted R-squared. The GDPPC, CDE, OP and TO are showing the p-value of 0.5770, 0.9228, 0.0001 and 0.000 respectively. There are two independent variables have remained statistically insignificant as their p-value are higher than their level of significant of 10%, 5% and 1%, which are GDPPC and CDE. In short, the p-value are larger than the significant level of 10%, 5% and 1%, therefore there are sufficient evidence to conclude that GDPPC and CDE are **statistically insignificance**. On the other hand, OP and TO are statistically significance as its p-value 0.0000. In short, there are sufficient evidence to conclude that OP and TO is **statistically significance** as its p-value is smaller than the significance level of 10%, 5% and 1%.

Based on Table 4.3, the FEM model has the greatest adjusted R-squared among the POLS model and the REM model. The FEM model has the value of 0.960800 of adjusted R-squared. In the FEM model, the gross domestic product (GDP) interact with TO showed a p-value of 0.4687. The independent variable has remained **statistically insignificant** because the p-value is greater than the level of significant of 10%, 5% and 1%. On the other hand, the CDEs (CO2) interact with TO and OP (OP) interact with TO are statistically significance as their p-value 0.0000 and 0.0001 respectively. In short, there are sufficient evidence to conclude that CO2 interact with TO and OP interact with TO are **statistically significance** as their p-value are lower than the significance level of 10%, 5% and 1%.

4.2.3 REM

From result of REM model in Table 4.2, the adjusted R squared of 0.789411 is equal to POLS model but lower than FEM model. The GDP, CO2, OP and TO are showing the p-value of 0.0000. In short, there are sufficient evidence to conclude that all four variables are **statistically significance** as their p-value are lower than the significance level of 10%, 5% and 1%.

According to Table 4.3, REM model displayed that its adjusted R squared of 0.725403 is greater than the POLS model's adjusted R squared. However, in REM model, there is an independent variable with interaction term has consisted a different sign from theoretical expectation which is GDPPC interact with TO. The GDPPC interact with TO is showing a p-value of 0.4711. In short, there is an **insufficient evidence** to conclude that the variable is statistically significance as its p-value higher than the significance level of 10%, 5% and 1%. On the other hand, the remaining two variables which are CDE interact with TO and OP interact with TO are statistically significant. These are due to their p-value of 0.0000 and 0.0001 respectively are lower than the significance level of 10%, 5% and 1%. To conclude the that the two variables are statistically significant, their p-value is smaller than the three significant levels.

Table 4.2: Panel Data Models for Model 1

Model 1			
	POLS	**FEM**	**REM**
C	-10.73879 (0.5695)	144.6781*** (0.0000)	-10.73879 (0.1888)
GDPPC	0.358318* (0.0838)	-0.052536 (0.5770)	0.358318*** (0.0001)
LOG (CDE)	-21.64848*** (0.0000)	-0.317825 (0.9228)	-21.64848*** (0.0000)
OP	-8.331844*** (0.0058)	6.930374*** (0.0001)	-8.331844*** (0.0000)

LOG (TO)	-5.056720*** (0.0051)	-10.08106*** (0.0000)	5.056720*** (0.0000)
R-squared **Adjusted R-squared** **D-W test stat**	0.796489 0.789411 0.091515	0.963435 0.960800 0.312814	0.796489 0.789411 0.091515

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

Table 4.3: Panel Data Models for Model 2

Model 2			
	POLS	**FEM**	**REM**
C	141.8663*** (0.0000)	115.6307*** (0.0000)	116.2093 (0.0000)
GDPPC*LOG (TO)	0.021848 (0.3312)	-0.005867 (0.4687)	-0.005834 (0.4711)
LOG (CDE*TO)	-9.454418*** (0.0000)	-7.145106*** (0.0000)	-7.169159 (0.0000)
OP * LOG (TO)	0.649138*** (0.0067)	0.486668*** (0.0001)	0.490784 (0.0001)
R-squared **Adjusted R-squared** **D-W test stat**	0.679975 0.671698 0.043430	0.963290 0.960995 0.278015	0.732325 0.725403 0.274734

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

4.3 Model Comparison

4.3.1 Model 1

From LR test, we can find out the test statistic is 130.3611 and p-value is 0.0000, which can conclude as significant. Because H1 is accepted at significant level of 0.01, 0.05 and 0.1. Hence, FEM is suitable model compared to POLS. In LM test, the test statistic found was 530.1207 and p-value is 0.000. And the H0 is rejected since the p-value is significant. From above result, we can conclude that REM is preferable compared to POLS. In short, we can know that FEM and REM is preferable compared to POLS.

To test which model is more preferable between FEM and Rem, Hausman test had performed. From Hausman test, the result show that test statistic is 506.794673 and p-value is 0.000. Therefore, reject H0 to conclude that REM is more suitable than FEM. In conclusion, REM was the best model for panel data for REC.

4.3.2 Model 2

To compare POLS model and FEM model, Likelihood Ratio (LR) had tested. From Table 4.5, the test statistic for LR test was 83.54051 with p-value of 0.0000. Therefore, H0 is being rejected at 10% (0.1), 5% (0.05) and 1% (0.01) of significant level. There is sufficient evidence to conclude that FEM model is suitable model compared with POLS model. LM test, which compare POLS model and FEM model showed the test statistic was 1024.578 and p-value was 0.0000. The H0 is rejected at significant of 0.1, 0.05 and 0.1. Therefore, we can conclude that REM model is model that desired compared to POLS model.

From LR and LM test, FEM model and REM model are preferable for Model 2. Therefore, Hausman test tested to find out which more suitable for Model 2. From Table 4.5, the test statistic was 0.729269 and p-value is 0.8663. The H1 is accepted since p-value is insignificant. Therefore, we can conclude that REM model is preferable to Model 2 compare to FEM model.

Table 4.4: Model Comparison for Model 1

Model 1			
	LR Test	**LM Test**	**Hausman Test**
TS	130.3611*** (0.0000)	530.1207*** (0.0000)	506.794673*** (0.0000)
DM	Reject null hypothesis	Reject null hypothesis	Reject null hypothesis
Conclusion	FEM is preferable	REM is preferable	FEM is preferable

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

Table 4.5: Model Comparison for Model 2

Model 2			
	LR Test	**LM Test**	**Hausman Test**
TS	83.54051*** (0.0000)	1024.578*** (0.0000)	0.729269 (0.8663)
DM	Reject null hypothesis	Reject null hypothesis	Do not reject null hypothesis
Conclusion	FEM is preferable	REM is preferable	REM is preferable

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

4.4 Diagnostic Checking

4.4.1 Multicollinearity

In addition, Variance Inflation Factors (VIF) is used to detect multicollinearity problem. Based on Eviews result for Model 1, under the Centered VIF, we can see that the variables in Model 1 have the Centered VIF that less than 10. Therefore, we can conclude that Model 1 has no multicollinearity problem. Other than that, based on the Eviews result for Model 2, under the Centered VIF, we can see that the independent variables of Model 2 have the Centered VIF that less than 10. Therefore, we can conclude that Model 2 has no multicollinearity problem.

4.4.2 Normality

Moreover, the Jarque-Bera test (JB test) had ran for normality test. Based on result for Model 1, the test statistic is 3.362264 and the probability is 0.186163. From the probability shown, we can conclude that the null hypothesis rejected due to the probability (0.186163) is larger than 0.05. Therefore, the error term in Model 1 is normally distributed. Furthermore, the result of Model 2 showed the test statistic is 5.027705 and the probability is 0.080956. From the probability shown, we can conclude that we should not reject the null hypothesis due to the probability

(0.080956) is greater than 0.05. Therefore, the error term in Model 2 is normally distributed.

4.5 Discussion

In Model 1, the real sign for OP was positive which consistent with our expected sign. The positive relationship between OP and REC was proven by Omri, Daly & Ngugen (2015). Meanwhile, CDE, GDPPC and TO have negative sign. Lahaini, Sinha & Muhammad Sbahbaz (2018) and Sebri & Salha (2014) was prove that there is a negative relationship between CDE and REC. While the negative relationship between GDPPC and REC was justified in Askar (2016). Lastly, negative relationship between TO and REC was supported in Sebri & Salha (2014). In Model 2, we found out there is positive relationship between OP*LOG(TO) and REC. Besides that, there is an inverse relationship between GDPPC*LOG (TO) and LOG(CDE*TO) with REC respectively.

4.6 Conclusion

In short, all variables were stationary in both models. The suitable model for Model 1 is FEM model, while REM model for Model 2. There were no multicollinearity problem and the error terms are normally distributed in both models.

CHAPTER 5: CONCLUSION

5.1 Summary of Finding

This research is studying on the impact of economic growth, CO2 emission, trade openness and oil price to the REC from the period 1991-2015 among the countries of ASEAN-5 which are Malaysia, Thailand, Indonesia, Philippine, and Vietnam. First of all, there are several tests have been carried out in our research which are panel unit root test, POLS, FEM, REM, LR, LM, Hausman test, VIF test and JB test. For panel unit root test, both models are stationary at 1%, 5% and 10% significant level in the level form. On the other hand, model 2 which is the interaction terms model give a result of all interaction variables are significant at level 1% in the level form.

To test the best model for Model 1 and Model 2, LR test and LM test was carried out and showed that POLS is not preferable as compared to FEM and REM for both models. In comparison of FEM and REM, the Hausman test showed a result of REM is the best model for model 1 while FEM is the best model for Model 2. After performing multicollinearity test, the result proved that model 1 and model 2best have no multicollinearity problem as both of the values in Centered VIF are less than 10. Meanwhile, model 1 and model 2 are normally distributed in the JB test.

5.2 Implication of Study

5.2.1 Low Carbon Cites Framework (LCCF)

In September 2011, Malaysia was established **Low Carbon Cites Framework (LCCF).** LCCF is a framework and assessment system to lead Malaysia cities become low carbon cities. The objectives of LCCF are measure the real carbon emission of the cities, guide local government in building a low carbon city and attract attention of Malaysian toward the concept of low carbon cities (Green Tech Malaysia, 2019). In July 2019, Green Tech Malaysia was launching Low Carbon Cities 2030 which aim to reduce 40% of carbon emission by 2030 (Khoo, 2019).

To achieve this goal, Green Tech Malaysia was taken action by install solar panels and the panels can generate up to 6,130kwh of clean energy of month. Although overall of REC in Malaysia from 1992-2015 had decreased, however, start from 2011 there was an increasing trend of REC in Malaysia. Last but not least, launching of LCCF also created awareness of Malaysia citizen and organization in building green and better environment, there was increase of 7.1% licensed capacity for renewable energy from 2015 to 2016 (Azlina Hashim, n.d.). We believe that the implementation of LCCF able to increase the consumption of renewable energy in long term. This is because the major contributor of carbon dioxide is non-renewable energy and to lower the carbon emission, switching of non-renewable energy to renewable energy was a best choice in long term.

5.2.2 Subsidy Reform Policy

The **Subsidy Reform Policy** can be defined as when the Government decided to reallocate or abolish the subsidies to the country's goods and services. Among the list of the subsidies in a country, the energy subsidy is one of the major burdens for a country. According to Asamoah, Hanedar and Shang (2017), the energy subsidies are costly which cause the country's public debt become greater or cut out the productive of public spending. Besides, the energy subsidy may bring damage to the nature environment, for example, when the subsidy of oil increase, will cause people to consume more on oil and then the CO2 emission will increase. At the end, the environment got affected. Therefore, the Subsidy Reform policy is able to solve the energy subsidy problem in short or medium term.

Knowing that, the Subsidy Reform policy is able to affect the oil price and lead to the consumption of renewable energy in the country. In Malaysia, the government does implement the subsidy reform policy on the subsidies for petrol, liquefied petroleum gas (LPG) and diesel in the year of 2010 (The Star Online, 2010). The Prime Minister's office announced that the subsidy reform is part of the gradual subsidy rationalization program. First, the subsidy for diesel and RON95 had been decreased by RM0.05 per litre while the subsidy for RON97 was removed. Besides, the subsidy of LPG had also decreased by RM0.10 per kilogram.

When the energy subsidies were reforming, the price of the oil and gas will increase and the people have to pay more on consuming the oil. Since the renewable energy is considered an alternative of the oil, people will search for a cheaper price of energy sources to consume it which is the renewable energy. Therefore, the REC will increase and the damage caused to the environment will be decreased too. Last but not least, Johansson and Goldemberg (2002) mentioned that the Subsidy Reform policy is one of the best policy options in promoting REC.

5.2.3 Trade Policy

Trade policy is the law applicable to the exchange of internationally exchanged goods or services, including subsidies, tariffs and import or export regulations (Business Dictionary, 2019). Trade policy also known as commercial policy. This policy directly influences the movement of trading goods and services. According to Thanawat, Peng, Liang and Yao (2013), the trade openness and economic growth have a positive relationship. When the trade openness increase in the countries, the growth of the economy will become faster. When the countries tighten the trade policy, the countries' economy will be benefited (Rodrik, Subramanian & Trebbi, 2004 and Rodriguez & Rodrik, 2001 as cited in Thanawat, Peng, Liang & Yao, 2013). There are various types of trade policies, including national trade policy, bilateral trade policy and international trade policy. By applying the trade policy, the production and the consumption between nations has no restriction. 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 the economics. For instance, Malaysia, one of the members of ASEAN countries and one of the world's most open economies, the 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 has an impact on the REC in an indirect way. When the trade policy has been tightened by the government, the economic growth will increase, the income of the public increase, thus, the usage of REC will increase. If the other ASEAN countries apply the trade policy too, the economic growth of the countries will increase too and this will lead to an increase of the usage of renewable energy.

5.3 Limitation

Furthermore, this research had recognized some weaknesses. First of all, there is insufficient data for our research. In this research, the time period that have been taken into account is year 1991 to 2015. The reason we take this time period is because the data for the renewable energy consumption for some countries that before and after this time period is missing. Other than this, the issues for the variable is difficult to get too. Due to these reasons, we decided to do the research for the year 1991 to 2015. Other than that, the proxy for oil price that we have used in this research is pump price of gasoline which have the unit measurement of US Dollar per litre. For most of the researches, the proxy of oil price will be US Dollar per barrel. The reason that we do not follow the proxy as the most of the researches is because there is insufficient data in the website as well as Bloomberg. Besides, some of the websites contain charges. Therefore, it is hard for us to use US Dollar per barrel as the proxy of oil price in this research.

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5.4 Recommendation

For the future researches, it is suggested that the respective department need to update the data of renewable energy consumption. This is to ease the researchers and can come out with a more accurate forecast. Once the researchers have a complete and reliable data, the results will be more accurate. Furthermore, when the respective department release the updated data, the government can produce more effective ways or schemes to increase the usage of renewable energy. When the usage or renewable energy increases, the country will have lesser carbon dioxide emission. Meanwhile, the air pollution of the country will reduce too.

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APPENDICES

Appendix 1: Model 1

Panel Unit Root

DV: Renewable Energy Consumption

Panel unit root test: Summary
Series: REC
Date: 02/29/20 Time: 22:57
Sample: 1991 2015
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-5.25772	0.0000	5	115
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-4.76343	0.0000	5	115
ADF - Fisher Chi-square	43.0716	0.0000	5	115
PP - Fisher Chi-square	50.0071	0.0000	5	120

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

IV: GDP per Capita

Panel unit root test: Summary
Series: GDPPC
Date: 02/29/20 Time: 22:58
Sample: 1991 2015
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-3.88038	0.0001	5	115
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-3.68441	0.0001	5	115
ADF - Fisher Chi-square	31.5010	0.0005	5	115
PP - Fisher Chi-square	42.2675	0.0000	5	120

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

IV: Log (CO2 emissions)

Panel unit root test: Summary
Series: LOG(CDE)
Date: 02/29/20 Time: 23:00
Sample: 1991 2015
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-2.01963	0.0217	5	115
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-0.00302	0.4988	5	115
ADF - Fisher Chi-square	8.28047	0.6015	5	115
PP - Fisher Chi-square	9.16479	0.5165	5	120

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

IV: Oil Price

Panel unit root test: Summary
Series: OP
Date: 02/29/20 Time: 23:01
Sample: 1991 2015
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-2.86644	0.0021	5	110
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-0.92921	0.1764	5	110
ADF - Fisher Chi-square	13.4952	0.1973	5	110
PP - Fisher Chi-square	3.27105	0.9743	5	115

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

IV: Log (Trade openness)

Panel unit root test: Summary
Series: LOG(TO)
Date: 02/29/20 Time: 23:01
Sample: 1991 2015
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-2.70755	0.0034	5	115
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-0.61079	0.2707	5	115
ADF - Fisher Chi-square	12.3201	0.2642	5	115
PP - Fisher Chi-square	16.2325	0.0932	5	120

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Pooled OLS

Dependent Variable: REC
Method: Panel Least Squares
Date: 02/29/20 Time: 23:02
Sample: 1991 2015
Periods included: 25
Cross-sections included: 5
Total panel (unbalanced) observations: 120

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-10.73879	18.82777	-0.570370	0.5695
GDPPC	0.358318	0.205428	1.744257	0.0838
LOG(CDE)	-21.64848	1.567871	-13.80757	0.0000
OP	-8.331844	2.962889	-2.812067	0.0058
LOG(TO)	5.056720	1.770579	2.855970	0.0051

R-squared	0.796489	Mean dependent var	30.55576
Adjusted R-squared	0.789411	S.D. dependent var	16.35842
S.E. of regression	7.506880	Akaike info criterion	6.910291
Sum squared resid	6480.624	Schwarz criterion	7.026436
Log likelihood	-409.6174	Hannan-Quinn criter.	6.957458
F-statistic	112.5202	Durbin-Watson stat	0.091515
Prob(F-statistic)	0.000000		

Fixed Effect Model

Dependent Variable: REC
Method: Panel Least Squares
Date: 02/29/20 Time: 23:02
Sample: 1991 2015
Periods included: 25
Cross-sections included: 5
Total panel (unbalanced) observations: 120

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	144.6781	16.89636	8.562680	0.0000
GDPPC	-0.052536	0.093912	-0.559414	0.5770
LOG(CDE)	-0.317823	3.272448	-0.097121	0.9228
OP	6.930374	1.743346	3.975329	0.0001
LOG(TO)	-10.08106	1.668286	-6.042761	0.0000

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.963435	Mean dependent var	30.55576
Adjusted R-squared	0.960800	S.D. dependent var	16.35842
S.E. of regression	3.238816	Akaike info criterion	5.260331
Sum squared resid	1164.382	Schwarz criterion	5.469393
Log likelihood	-306.6199	Hannan-Quinn criter.	5.345232
F-statistic	365.5857	Durbin-Watson stat	0.312814
Prob(F-statistic)	0.000000		

Random Effect Model

Dependent Variable: REC
Method: Panel EGLS (Cross-section random effects)
Date: 02/29/20 Time: 23:03
Sample: 1991 2015
Periods included: 25
Cross-sections included: 5
Total panel (unbalanced) observations: 120
Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-10.73879	8.123171	-1.321994	0.1888
GDPPC	0.358318	0.088631	4.042812	0.0001
LOG(CDE)	-21.64848	0.676452	-32.00297	0.0000
OP	-8.331844	1.278328	-6.517768	0.0000
LOG(TO)	5.056720	0.763910	6.619524	0.0000

Effects Specification

	S.D.	Rho
Cross-section random	1.01E-05	0.0000
Idiosyncratic random	3.238816	1.0000

Weighted Statistics

R-squared	0.796489	Mean dependent var	30.55576
Adjusted R-squared	0.789411	S.D. dependent var	16.35842
S.E. of regression	7.506880	Sum squared resid	6480.623
F-statistic	112.5202	Durbin-Watson stat	0.091515
Prob(F-statistic)	0.000000		

Unweighted Statistics

R-squared	0.796489	Mean dependent var	30.55576
Sum squared resid	6480.624	Durbin-Watson stat	0.091515

Hausman Test

Correlated Random Effects - Hausman Test
Equation: Untitled
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	506.794673	4	0.0000

Cross-section random effects test comparisons:

Variable	Fixed	Random	Var(Diff.)	Prob.
GDPPC	-0.052536	0.358318	0.000964	0.0000
LOG(CDE)	-0.317823	-21.648478	10.251328	0.0000
OP	6.930374	-8.331844	1.405134	0.0000
LOG(TO)	-10.081056	5.056720	2.199621	0.0000

Cross-section random effects test equation:
Dependent Variable: REC
Method: Panel Least Squares
Date: 02/29/20 Time: 23:04
Sample: 1991 2015
Periods included: 25
Cross-sections included: 5
Total panel (unbalanced) observations: 120

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	144.6781	16.89636	8.562680	0.0000
GDPPC	-0.052536	0.093912	-0.559414	0.5770
LOG(CDE)	-0.317823	3.272448	-0.097121	0.9228
OP	6.930374	1.743346	3.975329	0.0001
LOG(TO)	-10.08106	1.668286	-6.042761	0.0000

Effects Specification

Cross-section fixed (dummy variables)

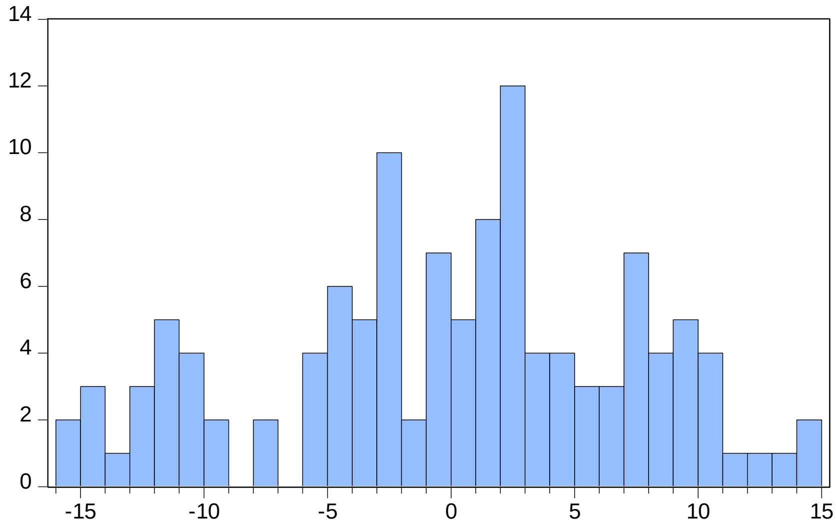
R-squared	0.963435	Mean dependent var	30.55576
Adjusted R-squared	0.960800	S.D. dependent var	16.35842
S.E. of regression	3.238816	Akaike info criterion	5.260331
Sum squared resid	1164.382	Schwarz criterion	5.469393
Log likelihood	-306.6199	Hannan-Quinn criter.	5.345232
F-statistic	365.5857	Durbin-Watson stat	0.312814
Prob(F-statistic)	0.000000		

Lagrange Multiplier Test

Lagrange Multiplier Tests for Random Effects
Null hypotheses: No effects
Alternative hypotheses: Two-sided (Breusch-Pagan) and one-sided (all others) alternatives

	Test Hypothesis		
	Cross-section	Time	Both
Breusch-Pagan	530.1207 (0.0000)	8.128207 (0.0044)	538.2489 (0.0000)
Honda	23.02435 (0.0000)	-2.851001 (0.9978)	14.26471 (0.0000)
King-Wu	23.02435 (0.0000)	-2.851001 (0.9978)	20.25312 (0.0000)
Standardized Honda	36.60174 (0.0000)	-2.675436 (0.9963)	13.64737 (0.0000)
Standardized King-Wu	36.60174 (0.0000)	-2.675436 (0.9963)	26.16786 (0.0000)
Gourieroux, et al.*	--	--	530.1207 (0.0000)

Normality Test



Series: Standardized Residuals
Sample 1991 2015
Observations 120

Mean	-1.18e-16
Median	0.575423
Maximum	14.33075
Minimum	-15.83954
Std. Dev.	7.379636
Skewness	-0.276000
Kurtosis	2.393577
Jarque-Bera	3.362264
Probability	0.186163

Multicollinearity (Variance Inflation Factors)

Variance Inflation Factors
Date: 02/29/20 Time: 22:46
Sample: 1 125
Included observations: 120

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	354.4847	754.8486	NA
GDPPC	0.042200	2.149496	1.017573
LOG(CDE)	2.458218	5.598176	3.316299
OP	8.778711	7.707575	1.799984
LOG(TO)	3.134949	913.1230	4.344234

Likelihood Ratio

Panel Cross-section Heteroskedasticity LR Test
Equation: UNTITLED
Specification: REC C GDPPC LOG(CDE) OP LOG(TO)
Null hypothesis: Residuals are homoskedastic

	Value	df	Probability
Likelihood ratio	130.3611	5	0.0000

LR test summary:

	Value	df
Restricted LogL	-409.6174	115
Unrestricted LogL	-344.4369	115

Unrestricted Test Equation:
Dependent Variable: REC
Method: Panel EGLS (Cross-section weights)
Date: 02/29/20 Time: 23:29
Sample: 1991 2015
Periods included: 25
Cross-sections included: 5
Total panel (unbalanced) observations: 120
Iterate weights to convergence
Convergence achieved after 11 weight iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-16.28131	8.709768	-1.869316	0.0641
GDPPC	0.025455	0.060513	0.420653	0.6748
LOG(CDE)	-25.76963	0.759317	-33.93790	0.0000
OP	3.665666	1.120978	3.270061	0.0014
LOG(TO)	5.526826	0.830684	6.653346	0.0000

Weighted Statistics

R-squared	0.958531	Mean dependent var	67.37864
Adjusted R-squared	0.957088	S.D. dependent var	44.54606
S.E. of regression	9.359216	Akaike info criterion	5.823948
Sum squared resid	10073.42	Schwarz criterion	5.940093
Log likelihood	-344.4369	Hannan-Quinn criter.	5.871115
F-statistic	664.5331	Durbin-Watson stat	0.483048
Prob(F-statistic)	0.000000		

Unweighted Statistics

R-squared	0.683670	Mean dependent var	30.55576
Sum squared resid	10073.25	Durbin-Watson stat	0.052651

Appendix 2: Model 2

Panel Unit Root Test

DV: GDP per Capita*Log (Trade Openness)

Panel unit root test: Summary
Series: GDPPC*LOG(TO)
Date: 02/29/20 Time: 23:20
Sample: 1991 2015
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-4.12384	0.0000	5	115
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-3.83489	0.0001	5	115
ADF - Fisher Chi-square	32.7703	0.0003	5	115
PP - Fisher Chi-square	44.9681	0.0000	5	120

** Probabilities for Fisher tests are computed using an asymptotic Chi
-square distribution. All other tests assume asymptotic normality.

IV: Log (CO2 emissions*Trade Openness)

Panel unit root test: Summary
Series: LOG(CDE*TO)
Date: 02/29/20 Time: 23:21
Sample: 1991 2015
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel
Balanced observations for each test

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-3.05921	0.0011	5	115
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-0.75653	0.2247	5	115
ADF - Fisher Chi-square	11.5410	0.3169	5	115
PP - Fisher Chi-square	17.4216	0.0655	5	120

** Probabilities for Fisher tests are computed using an asymptotic Chi
-square distribution. All other tests assume asymptotic normality.

IV: Oil Price*Log (Trade Openness)

Panel unit root test: Summary
Series: OP*LOG(TO)
Date: 02/29/20 Time: 23:22
Sample: 1991 2015
Exogenous variables: Individual effects
User-specified lags: 1
Newey-West automatic bandwidth selection and Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-2.72846	0.0032	5	110
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-0.70782	0.2395	5	110
ADF - Fisher Chi-square	12.7019	0.2408	5	110
PP - Fisher Chi-square	3.01703	0.9810	5	115

** Probabilities for Fisher tests are computed using an asymptotic Chi -square distribution. All other tests assume asymptotic normality.

Pooled OLS

Dependent Variable: REC
Method: Panel Least Squares
Date: 02/29/20 Time: 23:56
Sample: 1991 2015
Periods included: 25
Cross-sections included: 5
Total panel (unbalanced) observations: 120

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	141.8663	7.219153	19.65138	0.0000
GDPPC*LOG(TO)	0.021848	0.022388	0.975866	0.3312
LOG(CDE*TO)	-9.454418	0.617672	-15.30653	0.0000
OP*LOG(TO)	0.649138	0.235002	2.762273	0.0067

R-squared	0.679975	Mean dependent var	30.55576
Adjusted R-squared	0.671698	S.D. dependent var	16.35842
S.E. of regression	9.372981	Akaike info criterion	7.346305
Sum squared resid	10190.92	Schwarz criterion	7.439221
Log likelihood	-436.7783	Hannan-Quinn criter.	7.384038
F-statistic	82.15719	Durbin-Watson stat	0.043430
Prob(F-statistic)	0.000000		

Fixed Effect Model

Dependent Variable: REC
Method: Panel Least Squares
Date: 02/29/20 Time: 23:23
Sample: 1991 2015
Periods included: 25
Cross-sections included: 5
Total panel (unbalanced) observations: 120

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	115.6307	5.756333	20.08756	0.0000
GDPPC*LOG(TO)	-0.005867	0.008070	-0.727024	0.4687
LOG(CDE*TO)	-7.145106	0.513923	-13.90306	0.0000
OP*LOG(TO)	0.486668	0.123650	3.935852	0.0001

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.963290	Mean dependent var	30.55576
Adjusted R-squared	0.960995	S.D. dependent var	16.35842
S.E. of regression	3.230729	Akaike info criterion	5.247633
Sum squared resid	1169.012	Schwarz criterion	5.433466
Log likelihood	-306.8580	Hannan-Quinn criter.	5.323101
F-statistic	419.8433	Durbin-Watson stat	0.278015
Prob(F-statistic)	0.000000		

Random Effect Model

Dependent Variable: REC
Method: Panel EGLS (Cross-section random effects)
Date: 02/29/20 Time: 23:24
Sample: 1991 2015
Periods included: 25
Cross-sections included: 5
Total panel (unbalanced) observations: 120
Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	116.2093	9.050087	12.84069	0.0000
GDPPC*LOG(TO)	-0.005834	0.008069	-0.723009	0.4711
LOG(CDE*TO)	-7.169159	0.511707	-14.01028	0.0000
OP*LOG(TO)	0.490784	0.123301	3.980374	0.0001

Effects Specification

	S.D.	Rho
Cross-section random	15.71182	0.9594
Idiosyncratic random	3.230729	0.0406

Weighted Statistics

R-squared	0.732325	Mean dependent var	1.294383
Adjusted R-squared	0.725403	S.D. dependent var	6.108171
S.E. of regression	3.198952	Sum squared resid	1187.062
F-statistic	105.7873	Durbin-Watson stat	0.274734
Prob(F-statistic)	0.000000		

Unweighted Statistics

R-squared	0.636784	Mean dependent var	30.55576
Sum squared resid	11566.29	Durbin-Watson stat	0.028196

Hausman Test

Correlated Random Effects - Hausman Test
Equation: Untitled
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	0.729269	3	0.8663

Cross-section random effects test comparisons:

Variable	Fixed	Random	Var(Diff.)	Prob.
GDPPC*LOG(TO)	-0.005867	-0.005834	0.000000	0.7792
LOG(CDE*TO)	-7.145106	-7.169159	0.002273	0.6139
OP*LOG(TO)	0.486668	0.490784	0.000086	0.6575

Cross-section random effects test equation:
Dependent Variable: REC
Method: Panel Least Squares
Date: 02/29/20 Time: 23:24
Sample: 1991 2015
Periods included: 25
Cross-sections included: 5
Total panel (unbalanced) observations: 120

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	115.6307	5.756333	20.08756	0.0000
GDPPC*LOG(TO)	-0.005867	0.008070	-0.727024	0.4687
LOG(CDE*TO)	-7.145106	0.513923	-13.90306	0.0000
OP*LOG(TO)	0.486668	0.123650	3.935852	0.0001

Effects Specification

Cross-section fixed (dummy variables)

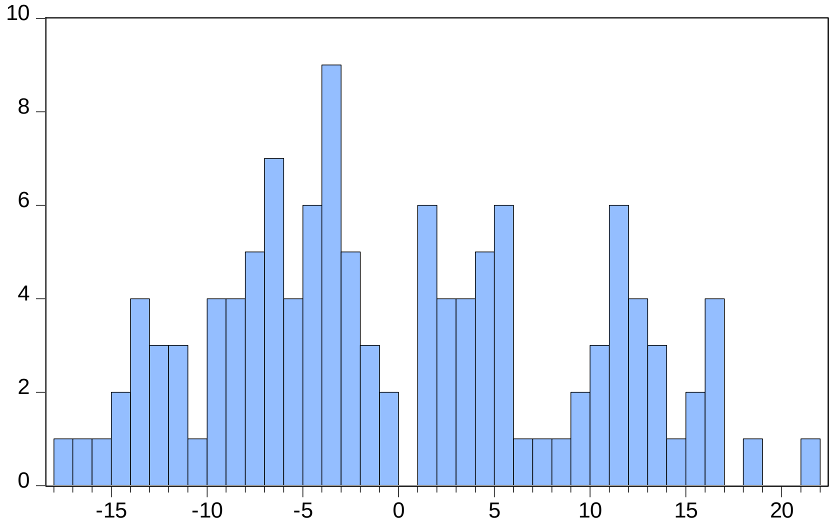
R-squared	0.963290	Mean dependent var	30.55576
Adjusted R-squared	0.960995	S.D. dependent var	16.35842
S.E. of regression	3.230729	Akaike info criterion	5.247633
Sum squared resid	1169.012	Schwarz criterion	5.433466
Log likelihood	-306.8580	Hannan-Quinn criter.	5.323101
F-statistic	419.8433	Durbin-Watson stat	0.278015
Prob(F-statistic)	0.000000		

Lagrange Multiplier Test

Lagrange Multiplier Tests for Random Effects
Null hypotheses: No effects
Alternative hypotheses: Two-sided (Breusch-Pagan) and one-sided
(all others) alternatives

	Test Hypothesis		
	Cross-section	Time	Both
Breusch-Pagan	1024.578 (0.0000)	11.72398 (0.0006)	1036.302 (0.0000)
Honda	32.00903 (0.0000)	-3.424030 (0.9997)	20.21265 (0.0000)
King-Wu	32.00903 (0.0000)	-3.424030 (0.9997)	28.35968 (0.0000)
Standardized Honda	43.03708 (0.0000)	-3.272405 (0.9995)	19.96597 (0.0000)
Standardized King-Wu	43.03708 (0.0000)	-3.272405 (0.9995)	33.70366 (0.0000)
Gourieroux, et al.*	--	--	1024.578 (0.0000)

Normality Test



Series: Standardized Residuals
Sample 1991 2015
Observations 120

Mean	2.03e-14
Median	-2.265059
Maximum	21.11259
Minimum	-17.76694
Std. Dev.	9.254080
Skewness	0.251825
Kurtosis	2.132891
Jarque-Bera	5.027705
Probability	0.080956

Multicollinearity (Variance Inflation Factors)

Variance Inflation Factors
Date: 02/29/20 Time: 22:50
Sample: 1 125
Included observations: 120

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	52.11617	71.18660	NA
GDPPC*LOG(TO)	0.000501	2.192445	1.018478
LOG(CDE*TO)	0.381519	80.38380	1.185075
OP*LOG(TO)	0.055226	4.568930	1.200738

Likelihood Ratio

Panel Cross-section Heteroskedasticity LR Test
Equation: UNTITLED
Specification: REC C GDPPC*LOG(TO) LOG(CDE*TO) OP*LOG(TO)
Null hypothesis: Residuals are homoskedastic

	Value	df	Probability
Likelihood ratio	83.54051	5	0.0000

LR test summary:

	Value	df
Restricted LogL	-436.7783	116
Unrestricted LogL	-395.0080	116

Unrestricted Test Equation:
Dependent Variable: REC
Method: Panel EGLS (Cross-section weights)
Date: 02/29/20 Time: 23:27
Sample: 1991 2015
Periods included: 25
Cross-sections included: 5
Total panel (unbalanced) observations: 120
Iterate weights to convergence
Convergence achieved after 7 weight iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	161.6871	3.369555	47.98472	0.0000
GDPPC*LOG(TO)	0.006871	0.012149	0.565546	0.5728
LOG(CDE*TO)	-11.49641	0.292175	-39.34773	0.0000
OP*LOG(TO)	1.570538	0.106779	14.70825	0.0000

Weighted Statistics

R-squared	0.938365	Mean dependent var	60.82370
Adjusted R-squared	0.936771	S.D. dependent var	66.44900
S.E. of regression	10.12115	Akaike info criterion	6.650134
Sum squared resid	11882.76	Schwarz criterion	6.743050
Log likelihood	-395.0080	Hannan-Quinn criter.	6.687867
F-statistic	588.6808	Durbin-Watson stat	0.261106
Prob(F-statistic)	0.000000		

Unweighted Statistics

R-squared	0.626821	Mean dependent var	30.55576
Sum squared resid	11883.56	Durbin-Watson stat	0.066262