

IS THERE POLLUTION HAVEN IN MALAYSIA?  
EXPLORING THE RELATIONSHIP AMONG  
FDI, CO<sub>2</sub>, GDP AND ENERGY CONSUMPTION

BY

ANUSSHA A/P S R VEERA KUMARAN  
HA SUIK KEE  
LEE JIA JIANN

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DEPARTMENT OF ECONOMICS

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## DECLARATION

We hereby declare that:

- (1) This undergraduate research project 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 research project 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 research project.
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Name of Student:	Student ID:	Signature:
1. <u>ANUSSHA A/P SR</u> <u>VEERA KUMARAN</u>	<u>12ABB02378</u>	_____
2. <u>HA SUIK KEE</u>	<u>12ABB02838</u>	_____
3. <u>LEE JIA JIANN</u>	<u>12ABB02608</u>	_____

Date: 20/4/2016

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## LIST OF ABBREVIATIONS

ADF	Augmented Dickey Fuller
AIC	Akaike Information Criterion
ARCH	Autoregressive Conditional Heteroscedasticity
BRIC	Brazil, Russian Federation, India and China
CO2	Carbon Dioxide
FDI	Foreign Direct Investment
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
JJ	Johansen and Juselius
LM	Lagrange Multiplier
MNC	Multinational Company
NASA	National Aeronautics and Space Administrator
OLS	Ordinary Least Square
PHH	Pollution Haven Hypothesis
PP	Phillips-Perron
SEA	South East Asia
SIC	Schwartz Information Criterion
VAR	Vector Autoregression
VECM	Vector Error Correction Model
VIF	Variance Inflation Factor

## PREFACE

Global warming has become one of the most pressing issues in our time with temperatures increasing at an alarming rate. World leaders have gathered to discuss this issue and find a feasible solutions to reduce the carbon dioxide emissions. Malaysia has also pledged to make efforts in reducing its carbon emissions by 45% by 2030. These efforts come from the fact that Malaysia has a relatively high CO<sub>2</sub> emissions per capita rate and ranks 37<sup>th</sup> in the world for the highest CO<sub>2</sub> emitter per capita. Malaysia is also making efforts in attracting FDI to compete with regional and developed markets

The PHH postulates that polluting concentrated firms tends to be attracted to a country with lax environmental policy. Therefore, a study is conducted to explore the relationship between the FDI and CO<sub>2</sub> emission in Malaysia which will determine the validity of this hypothesis. We include the variable of energy consumption and GDP in the study to explore how these economic factors affect the environmental health. This research will be helpful for policy makers to make proper decisions as they can observe the magnitude of the effects of these variables.

## ABSTRACT

This thesis paper aims to determine the existence of PHH in Malaysia. The effect of GDP, FDI and Energy Consumption on CO<sub>2</sub> emissions is studied in the case of Malaysia for the year 1971 – 2011. We use time series analysis by conducting VECM to study the long run and short run relationship. We also run Granger Causality to understand the causality relationship between the variables. It was found that the PHH is valid in the case of Malaysia. In the short run, FDI and GDP have a positive relationship with CO<sub>2</sub> emissions while Energy Consumption has a negative relationship. In the long run, FDI and Energy Consumption have positive relationship while GDP has negative relationship with CO<sub>2</sub> emissions. In the short run, there is also bidirectional causality between GDP and CO<sub>2</sub> emissions. There is also unidirectional relationship running from Energy Consumption to GDP and Energy Consumption to CO<sub>2</sub> emissions. In long run, there is unidirectional relationship from FDI, GDP and Energy Consumption towards CO<sub>2</sub> emissions.

## **CHAPTER 1: RESEARCH OVERVIEW**

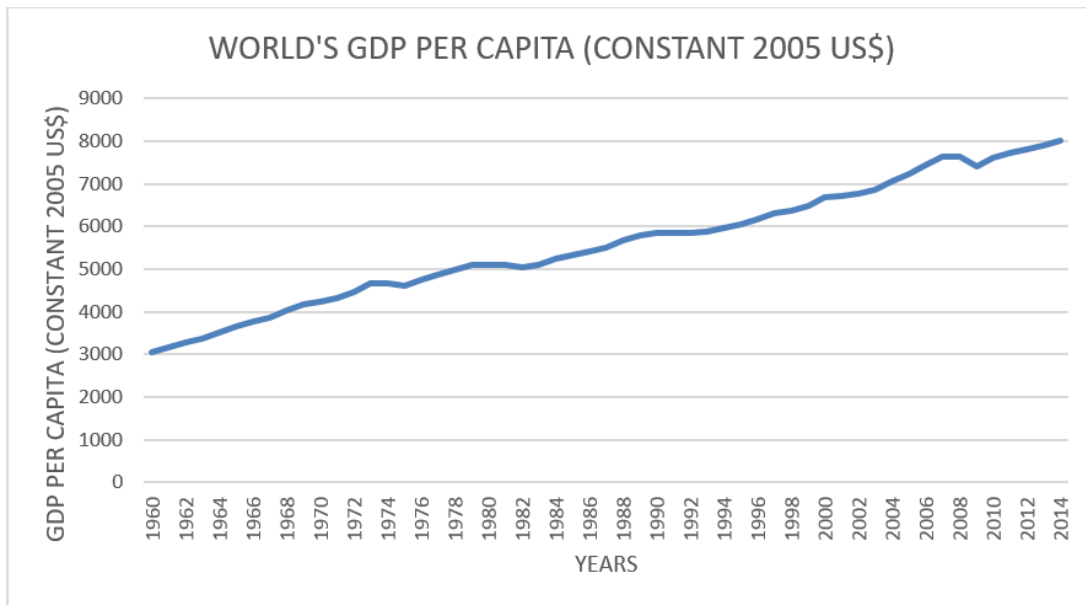
### **1.0 Introduction**

We will begin this research with a broad introduction on the effects of economic factors on the environment. It will focus on the impact that Foreign Direct Investments (FDI hereafter), Gross Domestic Product (GDP hereafter) and Energy Consumption has on carbon dioxide (CO<sub>2</sub> hereafter) emissions in Malaysia. The main theory that will be focused on is the Pollution Haven Hypothesis (PHH hereafter) that links FDI to the pollution level in the country. We will then narrow it down with the aid of graphs to illustrate the variables used in the case of Malaysia which includes GDP, FDI, Energy Consumption and the CO<sub>2</sub> emission. With that, this research paper will discuss the problem statement, after which, once the problem statement has been discussed, this chapter will include the research objectives, research question, hypotheses of the study and also the significance of this study. Lastly, this chapter will include an overall chapter layout for this research paper together with a conclusion for this chapter.

### **1.1 Research Background**

There is no doubt that the quest for economic evolution has been the main drive of almost every country. Over the years of progression, the world has continuously matured so much in terms of economics that it is astonishingly distinguishable from what we know as of today. Economic progress has been a tool of measurement used by many countries to measure their wellbeing and status (Chiok, Chong, Hoong, Liew & Ng, 2013). With that, we can observe the progress of the world's GDP which has grew an astonishing 161% (from US\$3066.33 in year 1960 to US\$8008.63 in year 2014) since the last half century (World Bank, 2016).

Figure 1.1: World's GDP Per Capita (Constant 2005 US\$)



Source: The World Bank. (2016). *World development indicator*. Retrieved from <http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators#>

FDI on the other hand is one of the essential variables in economic growth and development due to its utter significance as a foundation of capital which can boost the technological transfer among the countries (Al-mulali & Tang, 2013). The transfer of skills, knowledge or technology through the influx through FDI can significantly improve the current host country's labour working knowledge, spill over effects, better management function, better service and increasing the country's capital productivity. Additionally, bidirectional causality existed between the FDI inflow and GDP which proves the importance of FDI as one of the providers of a good economic growth (Aliyu, 2005; Kakar & Khilji, 2011; Omri, Nguyen & Rault, 2014). As the saying goes, "all good things must come to an end", the continuous race for a better country comes at a price where a sacrificial is obligatory to the world's environment where the FDI inflow also reflects as a key factor that may be the root of dreadful conditions of the environment (Omri, Nguyen & Rault, 2014). Thus, an enhanced understanding towards

the relationship among economic growth, Energy Consumption, FDI inflow and pollution level as a foundation for creating a strong economic policy in this research.

As the people are paying more attention to the world's health, it has been a focus of interest of many researchers to study the relationship between the pollution and its determinants. Up till today, the research of the relationship between FDI and the pollution level has produced a wide range of results.

According to Cole and Elliot, (2005); Cole, Elliot and Fredriksson, (2006); Wang, Gu, Tse and Yim, (2012), their research showed a positive relationship of FDI inflow towards the pollution level which means that the investments made towards the host country will further deteriorate the environment. Conversely, researchers such as Kirkulak, Qiu and Yin, (2011); Lan, Kakinaka, Huang, (2011); Atici, (2012) showed an inverse relationship among FDI inflow and pollution level which can be explained by the transferal of technologies focused on improving the environment from developed countries to a less developed or a developing country.

CO<sub>2</sub> emission has been one of the most popular instruments of indicators to measure the environmental level. With that being said, the amount of CO<sub>2</sub> emission has been increasing substantially which then being the main cause of global warming issue. Further studies on CO<sub>2</sub> emission and its danger to the world is explained in 1.1.1 Current issue.

Thus leading to our study of the PHH postulates that the pollution concentrated industries tend to be more attracted to less developed or developing countries compared to developed countries due to a lower stringent or weak environmental policy practiced by the less developed or developing countries. The existence of PHH can be proved when there is a positive relationship among FDI and pollution level. An example would be the inflow of FDI from the United State of America to Mexico or even Japan and Taiwan providing an inflow of FDI to the ASEAN countries (Al-mulali & Tang, 2013). The odds of the PHH arising in Malaysia would be possible due to the fact that their

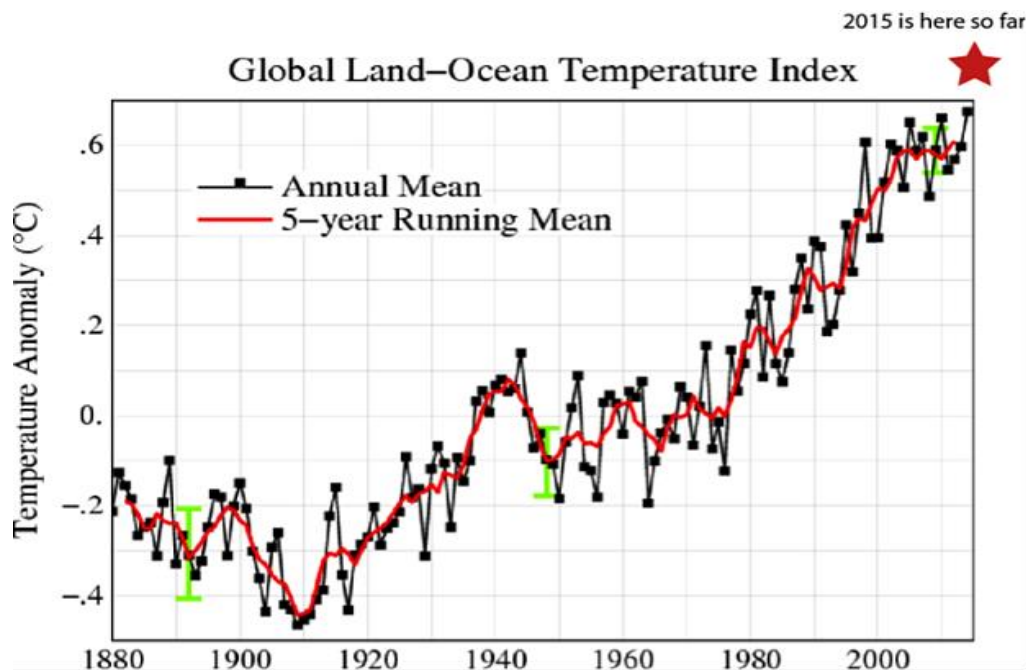


FDI has multiplied by 9.19 times and the CO<sub>2</sub> emission multiplied by 4.3 times in the last three decade (World Bank, 2016).

### 1.1.1 Current Issue

The environmental health of our planet has become one of the biggest concerns of our time. In the last decade more and more environmental problems have surfaced with one of it being global warming. Data from National Aeronautics and Space Administration (NASA hereafter) shows that the first five months of 2015 is the hottest start to a year ever recorded (National Aeronautics and Space Administration [NASA], 2016). The diagram below is used to compare what 2015 has been like to temperatures that we have experience so far. Besides the fact that 2015 is obviously much warmer than previous years, we can also see that temperatures have been increasing over the last century. NNOA/National Weather Service has predicted that there is a 90% chance that this will continue till early 2016 and 80% chance it will last till mid-2016.

Figure 1.2: Global Land-Ocean Temperature Index



Source: National Aeronautics and Space Administration. (2016). *GISS Surface Temperature Analysis*. Retrieved from [http://data.giss.nasa.gov/gistemp/graphs\\_v3/](http://data.giss.nasa.gov/gistemp/graphs_v3/)

Around the world, the impact of the global climate increase can be seen. Whitman (2015) of CNN reports that in India, the temperatures are nearing 50 degrees Celsius as the heat wave worsens leaving the death toll at 2330 in the beginning of June. The zebra crossings on the tar roads have also melted in New Delhi India (Lucas, 2015). Britain has also experienced the hottest day in July on record reaching up to 36.7 degrees Celsius and forecasters predicts that there will be much hotter weather in the future (“Hottest July Day”. 2015). Straits Times reports on the rising temperature around the world showing that many countries are experiencing unusually high temperatures (“Rising Temperatures”, 2015). Spain and Portugal have hit weathers above 40 degree Celsius and are on red alert (“Spain, Portugal bake in heatwave”, 2015). The heat went up to 44 degrees Celsius in Pakistan and claimed 1150 lives (Ellis, Saifi, Martinez, 2015). China also put out a yellow warning with temperatures reaching 39 degrees (Xinhua, 2015). In Malaysia, Fong et al. (2015) reports that hot and dry weather is expected to continue till the end of August. There have been long periods of little rain and the haze returns occasionally. The highest recorded weather has been between 37 to 38 degrees Celsius but is not expected to go above that. All over the world the heat is claiming lives and disturbing daily lives. It has become more than just a minor issue.

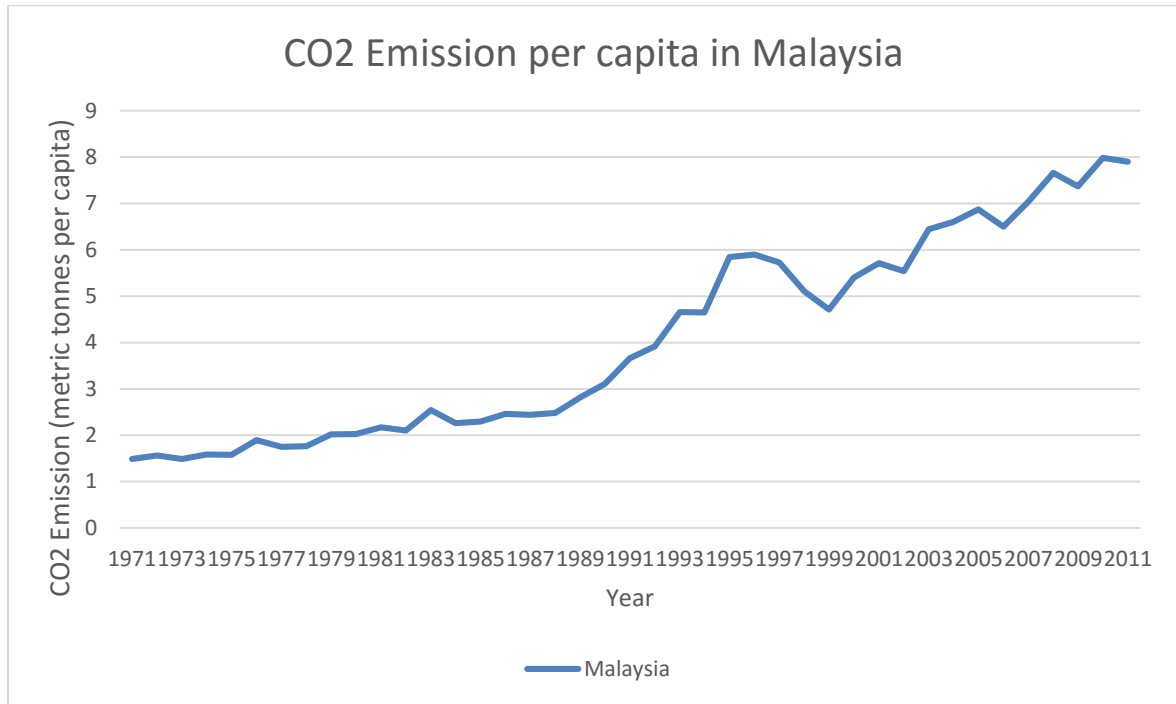
With this quickly becoming one of the biggest problems for people all over the world, the one question we all have is what is causing the heat waves? A study by Fischer and Knutti (2015), shows that 75% of heat waves is caused by climate change or better known as global warming. They go on to add that every degree of warming can cause some of the most rare and extreme events. Global warming is caused mainly by the emission of CO<sub>2</sub> that acts as a blanket in the atmosphere and traps the heat that would otherwise escape (Global Warming Causes, 2011). The trapped heat ends up warming up and raising the temperature of the planet. The phenomenon of extreme heat waves is due to human negligence and can be reversed with the correct efforts.

The leaders from IMF, World Bank and United Nations have gathered leaders from all over the world to discuss ways of tackling the current climate problems (Climate Finance, 2015). These leaders are coming together to gather funds to be used towards reducing global warming. All over the world people are looking towards being more sustainable and environmentally friendly with the availability of green technology. Every nation needs to make effort to be part of this movement as it affects the wellbeing of all of us as a whole.

### **1.1.2 CO2 Emission in Malaysia**

Malaysia is a country located in the South-Eastern Asian peninsula. From the past decades, Malaysia has transformed from a raw material production country such as rubber and palm oil to an emerging multi-sector economy. Malaysia was hit from multiple financial crisis which is the Asian Financial Crisis of year 1997 and the Global Financial Crisis of year 2009 but Malaysia managed to recover rapidly, also, Malaysia is categorized as an upper middle income country, this indicates that Malaysia has successfully decrease poverty and boosts economic growth. Unfortunately, the growth of the economy in Malaysia has brought a side effect to the Malaysia's environment which we will be looking at the graph in Figure 1.3.

Figure 1.3: CO2 Emission Per Capita in Malaysia



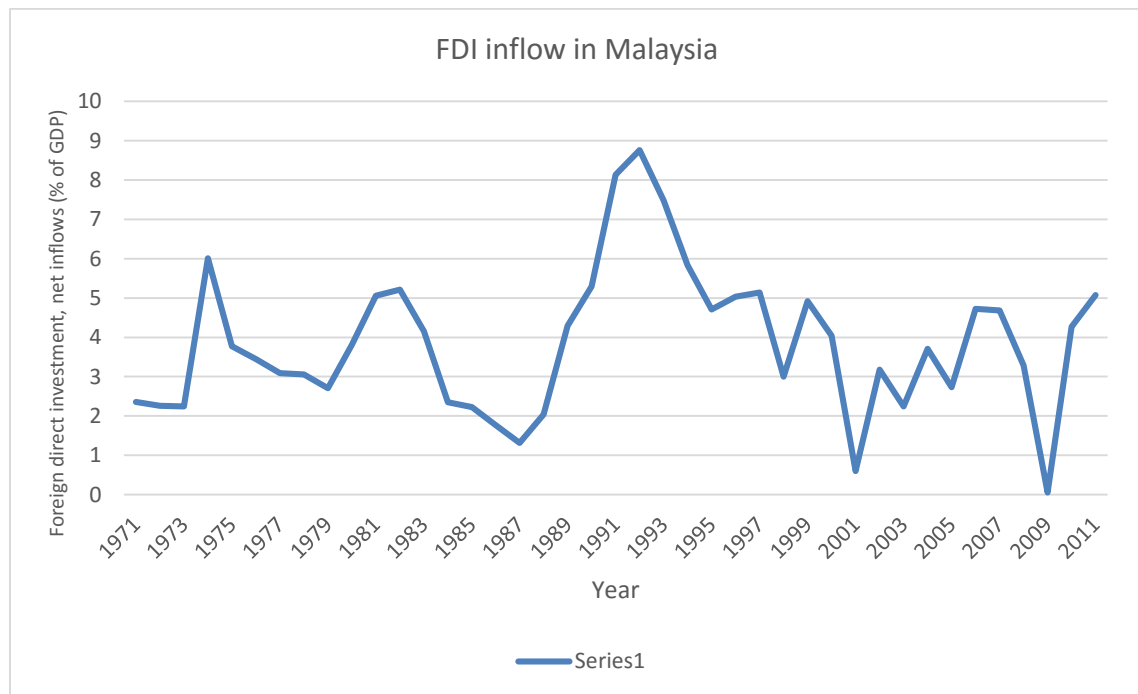
Source: The World Bank. (2016). *World development indicator*. Retrieved from <http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators#>

Figure 1.3 displays the CO2 emission per capita in Malaysia within the time period of year 1971-2011. In the year 1971, Malaysia has a CO2 emission of only 1.49 metric tonnes per capita and the CO2 emission rose up till 7.90 metric tonnes per capita in the year 2011. The graph showed that Malaysia maintained a steady growth of CO2 emission from the year 1972 to 1989 and then spiked up on the year after. Malaysia has an average growth rate of 4.63% per annum throughout the period of 1971 to 2011. During the year 1996 to 1999, there is a substantial drop in the CO2 emission with an average of -7.14% where it can be deduced from the Asian Financial Crisis from which the economy of Malaysia has slowed down leading to a lower emission of CO2. Moving on, CO2 emission continuously surged after the year 2009 until year 2011. The

continual in the increment of the CO<sub>2</sub> emission gave us the encouragement and the need to have a deeper look in the CO<sub>2</sub> emission situation in Malaysia.

### 1.1.3 FDI in Malaysia

Figure 1.4: FDI inflow in Malaysia



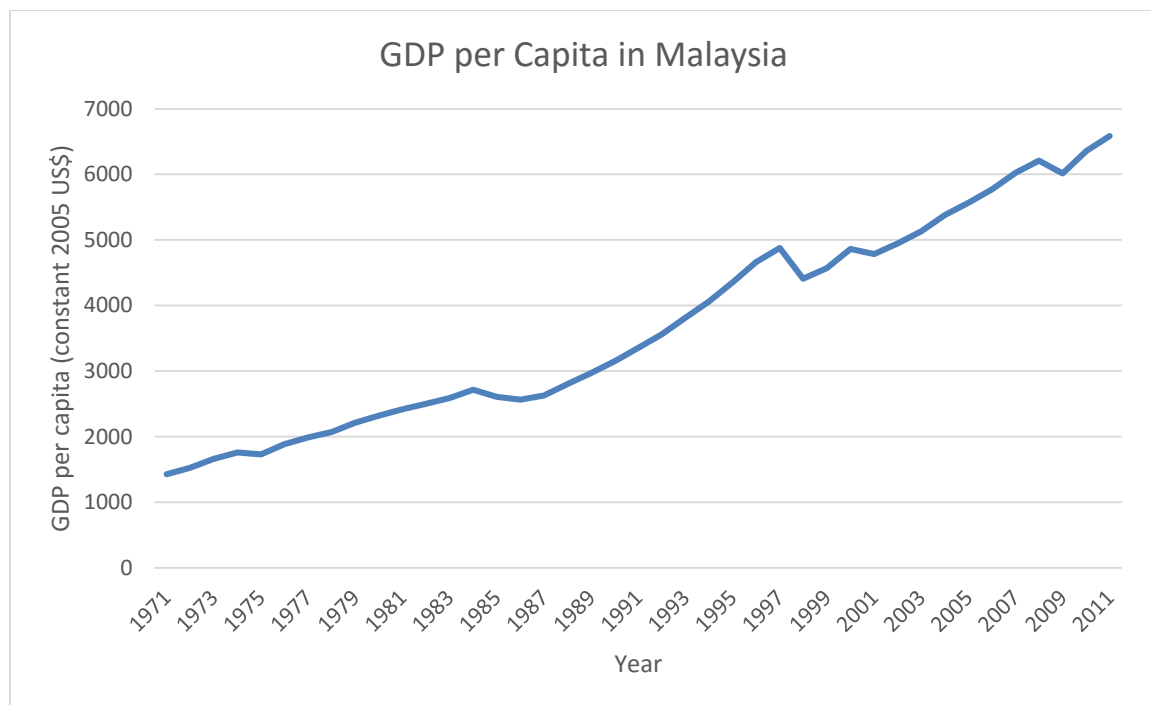
Source: The World Bank. (2016). *World development indicator*. Retrieved from <http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators#>

Figure 1.4 displays the FDI inflow per capita in Malaysia within the time period of year 1971-2011. The overall graph has some dramatic ups and downs throughout the years which were triggered by the financial crisis. During the year 1971, the FDI inflow was only 2.35% and it surged up to 5.07% of GDP in the year 2011 showing an increment of 115.74%. Throughout the year from 1971 to 2011, Malaysia experienced an average

growth in the FDI inflow of 200.30% per annum. The average figure may seem large but it's due to the changes especially during the crisis. We can see a significant drop in the FDI per capita especially in the year 1986, 1997, 2001 and year 2008 where each of the year experiences a crisis. In particular for the year 2009, the FDI inflow hit the lowest throughout the years (1971 to 2011) and at the same time in the year 2009, it acts as a turning point for the FDI inflows in Malaysia to rise back to average. The fluctuation of the FDI inflow in Malaysia indeed attracted the attention to study the relationship of the FDI inflow with the CO2 emission in Malaysia.

### 1.1.4 Economic Growth in Malaysia

Figure 1.5: GDP per capita in Malaysia

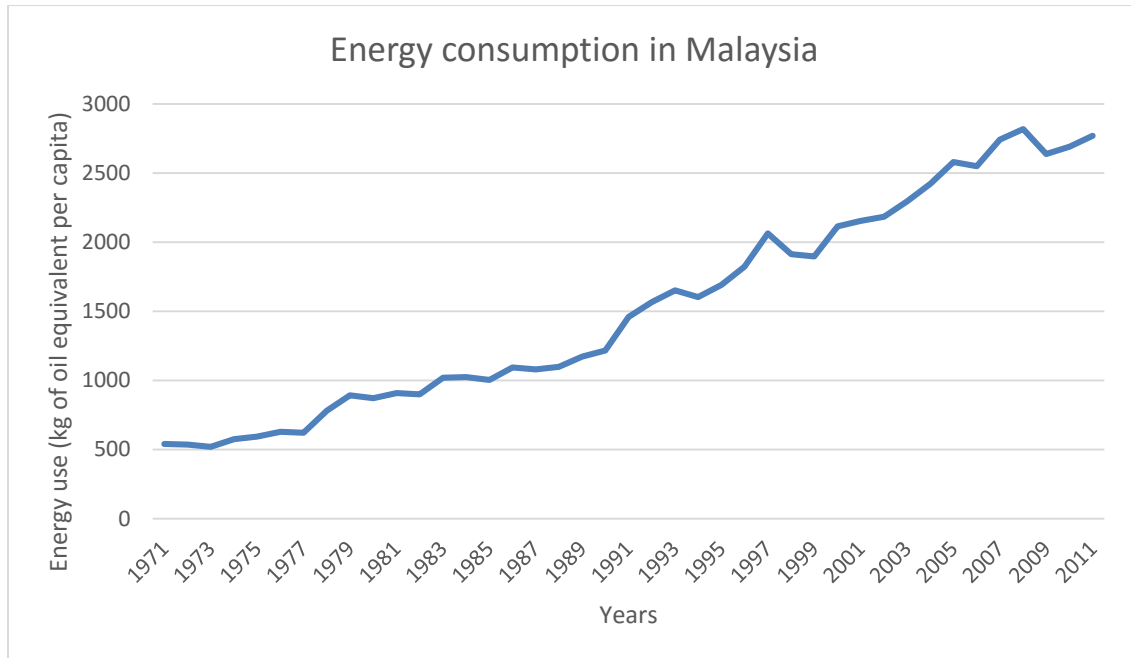


Source: The World Bank. (2016). *World development indicator*. Retrieved from <http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators#>

Figure 1.5 displays the GDP per Capita in Malaysia within the time period of year 1971-2011. Economic growth in Malaysia as measured through the GDP shows that there is an upward trend over the years. There is a dip in the economic growth during the years 1998 and 2009 during which there were financial crises in Malaysia. The 1997, the 7.4% dip can be accredited to the Asian Financial Crisis in which the Malaysian currency came under speculative attack and led to a full blown financial crisis (Ariff & Abu Bakar, 1999). About 10 years later, Malaysia was affected by another major financial crisis known as the Global Financial Crisis. It started out as an asset bubble in the US that quickly turned into a banking crisis and eventually became a worldwide financial crisis (Abidin & Rasiah, 2009). According to Abidin & Rasiah (2009), Malaysia faced a drop in their economic growth by 7.6% from the contraction of the external demand had a deep impact on the country because of their high export to GDP ratio. One of the constant debates among economists is about economic growth versus environment debate. According to Shafik & Bandyopadhyay (1992), countries with high economic growth may be subject to worse environmental qualities. For a country such as Malaysia where the GDP that has been rapidly increasing over the last 30 years, there could be an environmental impact.

### 1.1.5 Energy Consumption in Malaysia

Figure 1.6: Energy Consumption per Capita in Malaysia



Source: The World Bank. (2016). *World development indicator*. Retrieved from <http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators#>

Figure 1.6 displays the Energy Consumption per Capita in Malaysia within the time period of year 1971-2011. The overall trend of the graphs shows an upward moving graph. Through the graph, the Energy Consumption started off at 541.25 kg and surge to an astonishing 2,768.561 kg where there is an increment of 4.11% throughout the year from 1971 to 2011. Moreover the graph shows an average increasing rate of approximately 4.11% annually. We can also observe the fluctuations especially during the crisis in the year 1998 and year 2009. During the year 1998, the Energy Consumption has decreased due to the financial crisis that arisen in Asia. Same goes to year 2008 where another financial crisis occurred and the consumers are badly struck by the events. For both of the crisis, Malaysia was able to recover from the crisis and further increase the consumption of energy thereafter. With that, the data gives us the



incentives to have a better understanding on the Energy Consumption situation in Malaysia and also to perform a further study on the relationship among Energy Consumption with CO<sub>2</sub>.

## **1.2 Problem Statement**

The study regarding the pollution towards the earth has been the subject of attention among many researchers. Numerous studies has been conducted to explore the relationship among the pollution level and the FDI inflow with the addition of vast variables that shows significance in affecting the pollution level and the FDI inflow to validate the existence of PHH hypothesis such as CO<sub>2</sub> emission, GDP, FDI (Aliyu, 2005; Omri, Nguyen & Rauly, 2014; Hakmi & Hamdi, 2015) and energy consumption (Pao & Tsai, 2010; Pao & Tsai, 2011). Granting that there are abundant of research has been carried out, especially on the research of validating the PHH hypothesis, there is only a small amount of research that has been done to examine the long run relationship among CO<sub>2</sub> emission, FDI, GDP and Energy Consumption in the AND in particularly, to test for the existence of PHH hypothesis the case of Malaysia.

Kok (2014) mentions that the FDI in Malaysia grew by an impressive 22.2% in 2013 compared to the previous year. Chew (2016) adds that most of Malaysia's FDI had previously come from Singapore, Japan, Netherlands, US and Norway. However in 2015, China was the largest FDI in Malaysia. According to statistics at the World Bank (2016), the FDI inflow in Malaysia has an increasing trend where it multiplied by 9.19 times since the last three decades. Even though Malaysia's FDI has been increasing rapidly and there are still neighbour countries that have higher FDI inflow. CO<sub>2</sub> emissions have been on an increasing trend where it multiplied by 4.3 times since the last three decade and is reaching dangerous levels. This has garnered attention from all over the world and has led to countries pledging to reduce CO<sub>2</sub> emissions. According to NASA (2016), that there is a 90% probability that greenhouse gases has caused the

warming of planet earth. NASA also reports that the CO<sub>2</sub> levels have increase to 400 parts per million from 280 parts per million over the last 150 years. Due to human activity, 30 billion tonnes of CO<sub>2</sub> enters the atmosphere every year (Goodall, 2007). The increase in CO<sub>2</sub> emission has contributed to about 70% of the greenhouse effect (Houghton, 2004). Among the ASEAN country with the highest CO<sub>2</sub> emissions is Malaysia with 7.7 metric tons per capita (World Bank, 2016). Malaysia also ranks 37th highest CO<sub>2</sub> emitter per capita in the world.

There is an increasing trend in both the FDI and the CO<sub>2</sub> emissions. We can see that in Malaysia that even though the increase in FDI is not the highest among the ASEAN countries, the CO<sub>2</sub> emissions instead are the highest. It could be possible that the FDI that were attracted are from the polluting industries.

In 2008, Malaysia agreed to reduce CO<sub>2</sub> emissions by 40% during the United Nations Climate Change Conference (Hussain, 2009). In 2015, Malaysia pledged to reduce its CO<sub>2</sub> emissions by 45% by 2030 (Goh, 2015). Malaysia will submit its carbon reduction plan to the United Nations Framework Convention. With Malaysia pledging to reduce its carbon footprint, we would like to see if the strategies taken to improve economic growth are affecting the environmental health. Economic health is the main objective of every nation but Malaysia is also stressing the environmental health of the country. Therefore, it is important to see if there is a trade off or if in the case of Malaysia both environmental health and economic growth are directly proportional.

Through studying the effects of economic variables such as GDP, FDI and energy consumption on CO<sub>2</sub> emissions, we can see which one of these variables affect the environment more significantly. We also study the directional relationship to see how the variables affect each other. Lastly, we'll study the PHH to see if there exists a trade-off between FDI and CO<sub>2</sub> emissions.

## **1.3 Research Objective**

One the major concerns for every country is the economic growth of the country because it indicates the overall health of the country and the living standard of its citizens. One of the main ways of boosting the economy is accepting foreign investments into the country. However, this would have an effect on the environmental health of the host country. Some countries face a trade-off between the environmental health and the foreign investment inflow. However, not all countries face this trade off. Therefore we would like to investigate the existence of this trade-off in Malaysia.

### **1.3.1 General Objective**

This study is to explore the relationship among FDI, GDP, CO2 and Energy consumption and to determine the existence of PHH hypothesis in Malaysia from the year 1971 to 2011.

### **1.3.2 Specific Objective**

This study would like:

1. To study the short run and long run relationship between FDI and CO2 emission.
2. To study the short run and long run relationship between GDP and CO2 emission.
3. To study the short run and long run relationship between energy consumption and CO2 emission.
4. To study the long run and short run causal direction among FDI, CO2 emission, GDP and energy consumption in Malaysia.
5. To determine the validity of the PHH in Malaysia.

## 1.4 Research Question

With the objectives that were stated above, the following are the research questions for this study:

1. What is the nature (positive or negative) of the relationship in the short run and long run between FDI, GDP and energy consumption on CO2 emission in Malaysia?
2. What would be the long run and short run causal direction of FDI, GDP and Energy Consumption on CO2 emission in Malaysia?
3. Does the PHH exist in the case of Malaysia?

## 1.5 Hypotheses of the Study

Below are the hypotheses of our study:

H1: CO2 emissions and GDP is positively related in the short run.

H2: CO2 emissions and FDI is positively related in the short run.

H3: CO2 emissions and energy consumption is positively related in the short run.

H4: CO2 emissions and GDP is positively related in the long run.

H5: CO2 emissions and FDI is positively related in the long run.

H6: CO2 emissions and energy consumption is positively related in the long run.

H7: There is short run directional causality running from FDI, GDP and energy consumption to CO<sub>2</sub> emission.

H8: There is long run directional causality running from FDI, GDP and energy consumption to CO<sub>2</sub> emission

H9: The PHH is valid in the case of Malaysia.

## **1.6 Significance of the Study**

Previously, there have been studies that linked the economic growth and FDI in a country to the environmental health of a nation. Many researchers have used other theories to understand the trade-off between economic variables and the environment. However, research using the PHH is scarce. Our study aims to contribute to the body of knowledge by proving the existence of PHH in Malaysia. It will also test the relationship and directional causality of the variables which are FDI, GDP and Energy Consumption on the CO<sub>2</sub> emission in the short run and long run.

Most researchers have carried out their study in either developed or high income country (Al-mulali & Teng, 2013; Al-Mulali & Che Sab, 2012a; Danladi and Akomolafe, 2013; Pao and Tsai, 2011). With investigation of this study, the outcome in our research will help fill in the lack of literatures in examining the validity of PHH in the case of Malaysia. It will contribute to the studies that have been done to investigate if the PHH can be counted to be valid in developing Asian countries as the current set of literature is limited.

This research also serves as a wakeup call on the relationship between FDI and the pollution levels, so that the policymakers could come out with a strong enforcement to prevent the worsening of the environment before the consequence gets worsened

further. Global warming is one of the most pressing issues right now and this research could contribute to understanding the reasons for the negative impact on the environment.

## **1.7 Chapter Layout**

This study will consist of five chapters in total that will start with an introduction to the topic for study. This chapter will consist of the research background of our study and the problem statement which will explain the reasons this study is conducted. The objectives of the study will be discussed through the research objective which includes general and specific objective. It will also include the research questions, hypothesis of our study, and the significance of our study where we will mention the importance and how it may help future researcher, and lastly conclusion for the first chapter. Then, we have Chapter 2 which will include literature reviews on the variables that have been chosen for this study. This will also include a literature review on the PHH. This chapter will include the review on a model that is relevant to the research and a proposed model that will be used in the research. Chapter 3 will outline the methodology, theoretical framework, and model used in this study. This chapter will also describe the method which will be used to test the data for diagnostic checking and time series analysis. This results obtained will be further discussed in the following chapter. In Chapter 4, we will report and analyse the results from the estimation of the model. We will discuss the results based on the objective of the research. Lastly, in Chapter 5, we will conclude our study and summarize the major findings and provide policy implications and recommendations for future researchers.

## **1.8 Conclusion**

This chapter is a brief introduction into the study that we will be conducting. It starts off with explaining the research background and continues to explain the current issues that are faced today. We also look at the different variables that are chosen, the problem statement, the hypotheses, the objectives and the research questions. Then we look at the significance of the study and how the study can contribute to the body of knowledge. Finally we look at the layout of the entire research. This chapter will help us understand the objectives that we have for the study and give a clear direction of how the study will be conducted.

## **CHAPTER 2: LITERATURE REVIEW**

### **2.0 Introduction**

In this is second chapter, we will be reviewing the literatures from multiple authors to support our research. Firstly, we will be reviewing the dependant variable which is the CO2 emission by providing its brief definition, why did we choose CO2 emission as our dependant variable and other researchers that used the CO2 emission as their dependant variable. Moving on with the next part, we will be reviewing the independent variables where the method of reviewing will be done with almost the same way we explain the independent variable, CO2 emission but with added literature reviews on their relationship and causality with the dependant variable but more focus is given to FDI. After that, we will be reviewing the theoretical model used which is what we are basing our research on, the PHH and with that, we will compute a proposed theoretical or conceptual framework which we will be using for our research. Lastly, we will be including a conclusion to conclude this second chapter.

### **2.1 Review of the literature**

#### **2.1.1 The Dependant Variable - CO2 Emission**

According to the World Bank (2016), “CO2 Emission” is the by-product of the fossil fuels that has been burnt or even during the process of the cement manufacturing. From the PHH, we know that a foreign firm will pollute or import their “dirty” goods or production to a country with a less stringent or lax environmental policy. The CO2 emission that is used as our dependant variable is chosen to be used as a proxy for the pollution level which can also represent the laxity in the environmental policy.



Previously, there have been other researches that used CO<sub>2</sub> emissions as a proxy for environmental health to conduct their studies. Danladi and Akomolafe (2013) researched the effect of economic variables on the environment in Nigeria. In another study, Al-Mulali and Che Sab (2012a, 2012b) studied the impact of economic variables on the environment using CO<sub>2</sub> emissions as a proxy in 19 different countries. These countries include Antigua and Barbuda, Australia, Canada, China, Cyprus, Denmark, Iceland, Japan, South Korea, Malaysia, Malta, New Zealand, South Africa, St. Kitts and Nevis, Sweden, Switzerland, Thailand, United Kingdom and the United States. Al-Mulali and Tang (2013) also conducted a research in the Gulf Cooperation Council to study the effect of CO<sub>2</sub> emissions. In another study, Pao and Tsai (2011a, 2011b) studied the effects of CO<sub>2</sub> emissions on economic variables in Brazil, Russian Federation, India and China (BRIC hereafter). Hoffman, Lee, Ramasamy and Yeung (2005) studied the effects of CO<sub>2</sub> on economic variables in over 112 countries to find the effect of FDI on the environment.

Using CO<sub>2</sub> emissions as a proxy for pollution level is a choice that is further supported by researchers such as Al-mulali and Tang (2013), Al-Mulali and Che Sab (2012a, 2012b), Danladi and Akomolafe (2013), Hoffmann, Lee, Ramasamy and Yeung (2005), Pao and Tsai (2011a, 2011b) where the usage of CO<sub>2</sub> emission as a proxy for pollution level in their research. This is also further supported by the researchers in the case of Malaysia which are Ang (2008) and Azlina and Mustapah (2012) where CO<sub>2</sub> emission is used as a proxy for pollution level. Thus the choice for CO<sub>2</sub> emission to be used in our research is aligned with our aim to validate the existence of the PHH and also used to test the relationship and causality with other independent variable. The literature review of the CO<sub>2</sub> emission with the independent variables will be discussed in the following sub headings.

## **2.1.2 The Independent Variables**

### **2.1.2.1 The PHH, FDI and its Relationship with CO2 emission**

According to World Bank (2016), the FDI that we used in this research are in which the foreign investors has acquisition of at least 10% or greater in voting stocks in a firm or enterprise in the economy other than the foreigner's country itself. The basis of choosing FDI as one of our independent variable is that it is used to test for the existence of PHH together with CO2 emission where if there is a positive relationship among FDI and CO2, it is deemed that PHH exists (Al-mulali & Teng, 2013). Researcher Al-mulali and Teng (2013) also stated that FDI is also one of the important variables in affecting CO2 emission.

During our literature review, we have found that the relationship and its causality of FDI and CO2 emission showed varied results. There were some researches that showed a positive relationship between the FDI and CO2 emission which proves the existence of PHH but there are also other researches that showed a negative relationship among the FDI and CO2 which obviously proved that there is no PHH in that particular country. For the case of negative relationship among FDI and CO2 emission, it can be described that the FDI that flowed into the country brought in more cutting-edge and low carbon emitting technologies to the country that receives the FDI. In another words, the FDI that flows into the recipient country not only increases the productivity but also lowers the amount of CO2 emission. With this said, the existence of PHH is still debatable among countries.

Japan is amongst the countries in the Asian region that emphasises in investing overseas with focus to the South East Asia (SEA thereafter) region where researchers such as Cole and Elliot (2005) discovered that the CO2 emission levels are to be expected to increase due to the investment inflow to the SEA countries from Japan where industries focused on heavy polluting are the main investment brought from Japan. Besides that,

Wang, Gu, Tse and Yim (2012) found that in the case of China, the relationship among FDI and CO<sub>2</sub> emission is positive. Thus, according to Cole, Elliot and Fedricksson (2006), the researches that has been done illustrates that countries that have lax environmental policy tends to be a much favoured choice of investment by the polluting countries. A research done by Atici (2012) where the researcher ran a panel data to test the association of the variables which includes the Japan's FDI, CO<sub>2</sub>, output and also imports to the countries in the ASEAN region. The result from the research showed that the CO<sub>2</sub> emissions has a positive effect from the output and exports, but the CO<sub>2</sub> emission has no effect on the Japan's FDI in the countries in the ASEAN region. The results is consistent with the research done by Wu and Li (2011) where they obtained a negative relationship among FDI and CO<sub>2</sub> emission in the case of China where the pollution level is not affected by the FDI. The researcher further supply reasons that the root of the pollution in the recipient country are not caused by the industries or firms owned by the foreigners where they argued that the FDI that they have brought in has a better structure in terms of technology in its industry compared to the domestic industry or firms. It is further supported by researchers such as Kirkulak, Qiu and Yin (2011), Lan, Kakinaka, and Huang (2011) and List, McHone and Millimet (2004) which produced similar results in the case of Unites States and China thus deducing that the FDI inflow to the recipient country encourages the transfer of technology where the efficiency in the usage of the resources are practiced to lessen the amount of CO<sub>2</sub> emission that causes the pollution level to rise.

There are also researchers that are able to show the existence of PHH. A research done by He (2006) found a positive relationship between the FDI with the CO<sub>2</sub> emission in China where the researcher tested the existence of PHH in the industries located in the Chinese provinces. Researcher which is Cole, Elliot and Zhang (2011) also proved the presence of PHH by using data which includes 112 main metropolises located in China. The result showed a positively significant effect of the FDI towards the pollution levels. Other than that, there are researches done in less developed or developing countries and also in Mexico which shows the presence of PHH where the FDI has a positive relationship with the pollution level (Jorgenson, 2009; Waldkirch & Gopinath, 2008).

Nevertheless, there is research done in the case of Malaysia for example Lau, Chong, and Eng (2014) shows there is a positive relationship between FDI and CO<sub>2</sub> emission. The above-mentioned reviews of literature displays that FDI is one of the main components of pollution.

### **2.1.2.2 GDP and its relationship with CO<sub>2</sub> emission**

According to World Bank (2016), GDP per capita is derived from the division of the GDP with the data of the midyear population. The GDP itself is obtained from the addition of the gross value summed up by all of the local producers together with the taxes in the product and deducting any available subsidies which are not accounted into the product's value. The calculation is made without the consideration of depreciation, depletion and degradation of assets or natural resources. The GDP per capita is in the term of the current U.S. dollar.

GDP is considered in the CO<sub>2</sub> emission model is due to the huge role it plays as the determinant for the CO<sub>2</sub> emission and we discovered a linear relationship amongst the variables (Al-mulali & Che sab, 2012; Ang, 2007; Hossain, 2011 and Pao & Tsai 2011). However, researchers such as Esteve and Tamarit (2012) and Wang (2012) experienced a different result to which they found a negative relationship amongst the variables.

The studies conducted by Kim, Lee and Nam (2010) have showed a robust relationship between the growth of the economy and the CO<sub>2</sub> emission which exhibits an expectation for the CO<sub>2</sub> mitigation to increase as the Korean economy continues to grow. Another research with the same result studied in the case of European countries such as Denmark, Italy, Germany, Greece and Portugal which showed a positive long run relationship amongst the variables growth of the economy with the CO<sub>2</sub> emission (Acaravci & Ozturk, 2010).

A research done by Xepapadeas (2005) which shows a positive relationship among the CO<sub>2</sub> emission and GDP, similarly, the research done by Say and Yucel (2006) discovered a positive relationship amongst the CO<sub>2</sub> emission and GDP from the time frame of 1970 to 2002. Whereas for the researchers Chebbi, Olarreaga and Zitouna (2009) and Managi (2006) found a negative relationship between the CO<sub>2</sub> emission and GDP by using a cointegration analysis in the long run.

In the case of Malaysia, researchers found different result of the relationship among GDP and CO<sub>2</sub> emission. In the research done by Ang (2008) reveals a positive relationship among GDP and CO<sub>2</sub> emission. This statement is supported by Azlina and Mustapah (2012) after they analysed their collected data. However, in the study of Saboori, Sulaiman, and Mohd (2012) shows a result of decreasing CO<sub>2</sub> emission when GDP increases.

### **2.1.2.3 Energy Consumption and its Relationship with CO<sub>2</sub> Emission**

According to Word Bank (2015), Energy Consumption is the usage of primary energy before it transforms to an end-use fuel. In this era, the rapid growth of the economy has caused consumption of energy to increase and at the same time pollution happens. Since the dependant on energy consumption rises annually, it leaves a big problem to the world in the coming years; we may need alternatives or sustainable renewable energy to support our economy in future. Also, the selection of Energy Consumption is because energy is the main instrument in developing the economy (Sahir & Qureshi, 2007). However, its total supply to an economy is uncertain (Zaleski, 2001). Energy Consumption is taken into account in our research is because this variable is ignored in the growth process by most of the traditional growth theories where they focus more on labour, capital, and so on (Stern & Cleveland, 2004).

In the research done by Lean and Smith (2009), they found out that there is a significant long run positive relationship among Energy Consumption and CO<sub>2</sub> emissions, where in this case they used a Vector Error Correction Model (VECM thereafter) in a panel form for the time frame from 1980 to 2006 for five ASEAN countries. However, based on journal done by Lotfalipour, Falahi, and Ashena (2010), they found a bidirectional relationship from Energy Consumption to CO<sub>2</sub> emission; while no causal relationship moving from Energy Consumption to CO<sub>2</sub> emission in the case of Iraq.

In the case of South Africa, a positive effect of CO<sub>2</sub> emissions on Energy Consumption was found (Menyah & Rufael, 2010). While in the case of Middle East and North African countries, Arouri et al. (2012) discovered a long-run positive significant effect of Energy Consumption on CO<sub>2</sub> emissions and in their case, they used the boot strap panel unit root test method to determine the connection between the CO<sub>2</sub> emission and the Energy Consumption in the time frame of 1981 to 2005. This is further supported by the research done by Niu et al. (2011) where their research shows a positive relationship among Energy Consumption and CO<sub>2</sub> emissions in the case of eight Asian economies. In the case of Malaysia, researchers also support the above statement where they found a positive relationship between Energy Consumption and CO<sub>2</sub> emission (Ang, 2008; Hossain, 2011; and Mugableh, 2013). In the other hand, Arouri et al (2012) found out that the use of the CO<sub>2</sub> emission per capita in developing countries is lesser than developed countries but when it comes to per unit of energy, CO<sub>2</sub> emission in developing countries is higher than developed countries.

## **2.2 Review of Relevant Theoretical Models**

There have been various studies that have been carried out to analyse the PHH that studies the linkage between FDI and CO<sub>2</sub> emissions. However, the number of studies done in ASEAN countries is very few. The PHH shows that FDI either have the ability to bring in investments from ‘dirty’ industries that increases the pollution in countries that are developing. FDI could also bring in industries with green technology or high

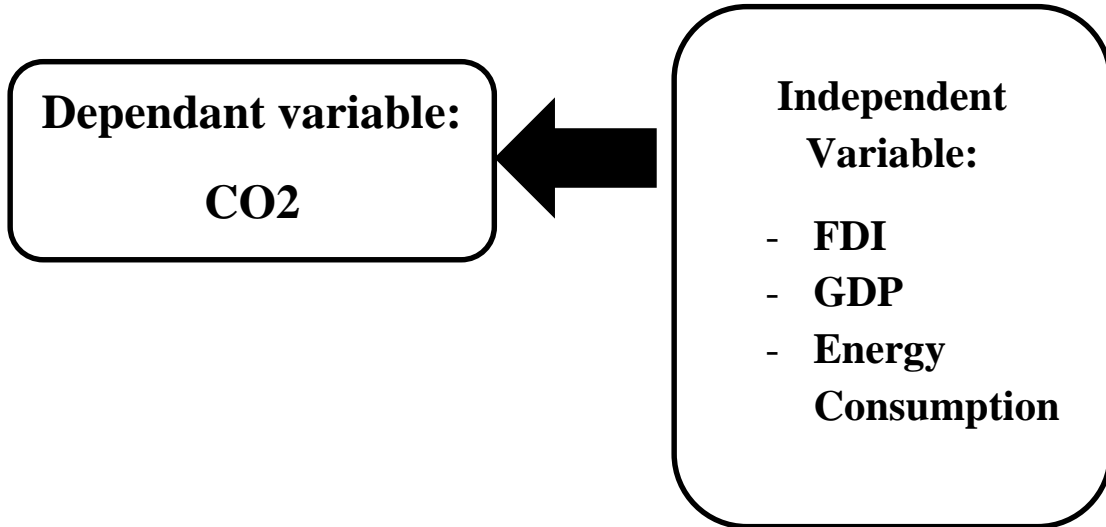
technology equipment that could help reduce CO<sub>2</sub> emissions. We have included this variable to study what kind of FDI a developing country such as Malaysia brings in, considering that Malaysia is competing with its neighbouring countries to attract FDI.

The PHH is a more pessimistic view on the relationship between the economic growth through fdi and the environment. Riddel (2010) states that the lax environmental rule in developing countries will lead the country accepting more pollution heavy industries for foreign investments. Peters and Hertwich (2008) state that it is much efficient to produce in a country where there is an environmental comparative advantage. Copeland and Taylor (2004) mention that comparative advantages such as low wages or weak environmental regulations could be considered as a comparative advantage which could lead to the occurrence of the PHH. Neequaye and Oladi (2015) states that environmental quality can be considered a normal good and therefore not a necessity in every country. This is the main reason why developing countries have more lax environmental rules. This would give incentive for dirty and polluting industries to move investments to countries with weaker environmental regulations.

There have been many researchers whom also agreed that the difference in environmental policies will affect the emergence of PHH in different countries because polluting activities are relocating to areas with weaker regulations (Jaffe et al., 1995; Copeland and Taylor, 2004; Brunnermeier and Levinnson, 2004; Taylor, 2004). This hypothesis helps us link FDI and the other economic variables to the environmental health of the country.

## 2.3 Proposed Theoretical/ Conceptual Framework

Figure 2.1: Researcher's Model



Adapted from: Al-Mulali, U., Tang, C. F., (2013). Investigating the validity of Pollution Haven Hypothesis in the gulf cooperation council (GCC) countries. *Energy Policy*, 60, 813-819.

The figure above (Figure2.1) displays the theoretical model used by Al-mulali and Tang (2013) to investigate the existence of the PHH in the GCC countries with a panel data with the time frame of year 1980 to 2009. This research is used to study the relationship between the variables and to test its causality in the short and long run. From the model, the variables used are CO2 emission per capita, GDP per capita, FDI per capita and Energy Consumption per capita. All of the data are taken from the World Development Indicators and form the Energy Information Administration. The dependent variable used is the CO2 emission per capita whereas the independent variables are FDI per capita, Energy consumption per capita and GDP per capita. The researcher used panel unit root test to test for stationarity which includes ADF-Fisher and PP-Fisher to obtain panel result where the null hypothesis used contains panel unit root where the alternative hypothesis shows that the individual panel series shows a



stationary result. Next, the researcher used the Panel co-integration test and lastly the granger causality test to test for directional causality.

With the reference of the econometric model from Al-mulali and Teng (2013), this research has adopted the model but with the note that our research is based on Malaysia only.

Thus having a model of:

$$CO_2 = \beta_0 + \beta_1 FDI + \beta_2 EC + \beta_3 GDP + \varepsilon$$

Where the dependant variable is CO<sub>2</sub> emission per capita (CO<sub>2</sub>) and the independent variables are FDI inflow (FDI), Energy Consumption per capita (EC) and GDP per capita (GDP). This study is based on the case of Malaysia from the time frame of year 1971 to 2011 based on the availability of data. CO<sub>2</sub> emission used acts as a proxy for pollution level which can also represents the laxity of the environmental policy. The FDI inflow represents the inflow of investments from the foreign country to Malaysia. For the GDP per capita, it is used to represent the wellbeing of the country. Lastly is the Energy Consumption which shows the by-product of the burning of fossil fuels. In this study, we will be testing the relationship between the variables and also the directional causality among the variables. We will focus on determining the existence of the PHH in Malaysia.

## **2.4 Conclusion**

Thus, the literature review on each of the variable, relationship among the variable and the PHH has been reviewed. We first looked at all the different researchers that use CO<sub>2</sub> emissions as the proxy for environmental health. Then we looked at each independent variable and their relationship with CO<sub>2</sub> emissions based on previous studies. These variables are FDI, GGP and Energy Consumption. All relationship

among variable are proven either to have negative or positive relationship and either they have causality or no causality. This gives a better understanding of the variables and what to expect next in the way of how we would run our test in the next chapter. Then we look at the theoretical framework that can be established based on literature review. The framework that centres this entire research is the PHH. We look at the main theory of this hypothesis which connects FDI to the environmental pollution. Lastly, we look at the conceptual framework that was adapted from the literature review.

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## **CHAPTER 3: METHODOLOGY**

### **3.0 Introduction**

The research methodology has been designed to conduct a study on the relationship of CO<sub>2</sub> emissions, GDP, FDI and energy consumption. The literature review that has been done in previous chapters has aided in building the econometric model for this study. This chapter will include our econometric model and data collection methods.

The first thing we do is a preliminary analysis to check if the data is stationary and to determine the descriptive statistics of the data. The research will move on into model estimation to establish a suitable model. This will be done by tabulating the descriptive statistics to get the information about the mean, median and standard deviation of the data. We are also able to check if the data is normally distributed. Then we will go on to test the stationarity of the data. Then we will explain model estimation to find a suitable model for our research. We also include diagnostic checking to ensure our model does not suffer from any problems. The cointegration of the data will be tested before choosing the suitable model for it. In the presence of cointegration, we will opt for the VECM model. Otherwise, we will use the Vector Autoregressive (VAR hereafter) model. Lastly we will check for causality using Wald Test to test for Granger Causality. Diagnostic checking will be done to make sure that our research. We will check for normality, heteroscedasticity, autocorrelation, multicollinearity and correct model specification. We will be using Eviews software as a tool to help us conduct our study.

Using this research method we would be able to answer our hypotheses stated in the earlier chapters. Long run and short run relationship between variables can be detected. The causality between the variables can also be detected. Lastly, we will be able to see the existence of the PHH theory in Malaysia.

### 3.1 Econometric Model

The theoretical framework that we have utilized in this research is the PHH. It mainly studies the relationship between pollution emissions and foreign investments. We have used CO2 emissions as a proxy for pollution level and FDI as a proxy for foreign investments. We also include economic growth and energy use into our model.

The econometric model for the CO2 emission in Malaysia that is derived from the literature review that has been done in the previous chapters is as follows:

CO2 = f (Gross Domestic Product, Foreign Direct Investment, Energy Consumption)

$$CO2_t = \beta_0 + \beta_1 GDP_t + \beta_2 FDI_t + \beta_3 ENERGY_t + \varepsilon_t$$

The model above is the basic model used for our research.  $CO2_t$  refers to CO2 emissions at time t.  $\beta_0$  refers to the intercept of the equation at time t.  $\varepsilon_t$  refers to the error term at time t.  $\beta_1 GDP_t$  refers to GDP per capita at time t.  $\beta_2 FDI_t$  refers to FDI at time t.  $\beta_3 ENERGY_t$  refers to energy consumption at time t. The data set that is being studied is from 1971 to 2011.

$$CO2_{t-1} = \beta_0 + \beta_1 GDP_{t-1} + \beta_2 FDI_{t-1} + \beta_3 ENERGY_{t-1} + \varepsilon_{t-1}$$

In the event of a non-stationary data, the model will include lagged variables.  $CO2_{t-1}$  refers to lagged CO2 emissions at time t.  $\beta_0$  refers to the intercept of the equation at time t.  $\varepsilon_{t-1}$  refers to the error term at time t.  $\beta_1 GDP_{t-1}$  refers to lagged GDP per capita at time t.  $\beta_2 FDI_{t-1}$  refers to lagged FDI at time t.  $\beta_3 ENERGY_{t-1}$  refers to lagged energy consumption at time t. The data set that is being studied is from 1971 to 2011.

## **3.2 Data Collection**

### **3.2.1 Carbon Dioxide Emissions**

The CO<sub>2</sub> emissions here are specified as the emissions that originate from the conversion of fossil fuel and the production of cement. This data set also includes CO<sub>2</sub> emissions that are produced during gas flaring and the use of fuels, whether solid, liquid or gas (World Bank, 2016). We have chosen to use the CO<sub>2</sub> emissions in the form of metric tons per capita to find out how much CO<sub>2</sub> is emitted for every person in the population. This will help us study the amount of emission relative to the country's population size instead of just the total amount.

### **3.2.2 Gross Domestic Product**

GDP is the gross value of all products that are produced in the economy and includes any product taxes. It does not take into account any subsidies that are not comprised in the value of the products. Deductions for depreciation of assets and degradation of any natural resources are not included in the calculation. The data that has been used is in per capita and has been divided by midyear population. The data that is used is in current US dollar (World Bank, 2016). This form of GDP is used measure the monetary value of growth for each person in the population. The amount of change in the economic growth can be seen not just in total but relative to the size of the country.

### **3.2.3 Foreign Direct Investment**

FDI is the total of the direct investments that enter into an economy. It is an investment from another economy and the investor from the foreign economy has substantial

impact in the organization of the enterprise. Part of the criteria for an existing direct investment relationship is the ownership of at least 10 percent of voting stock in a firm in the home country. The data that is used is in percentage of GDP form (World Bank, 2016). The total amount of FDI is divided by the economic growth in the country. This way we can see how much FDI was attracted into the country relative to the economic growth.

### **3.2.4 Energy Consumption**

Energy consumption is defined as utilized primary energy that has not been transformed into end use fuels. It can also be classified as the sum of native production, imports and stock change. However, it excludes exports and fuels that are used in international transport. The data that is being used is in kg of oil for per capita (World Bank, 2016). The data for energy consumption is also used in per capita form to see how much energy consumption there is for each person in the population. This will give us a more accurate estimation as we can take a look at the data relative to the size of the country instead of the absolute value.

All the data collected has been retrieved from the World Bank under the section World Development Indicators. World Bank has collected data from multiple sources and is a reliable source for data collection. The data that is collected is secondary data that has already been archived previous. All data that has been collected is from the year 1971 to 2011.

The data that has been collected is used to find the short run, long run and causal relationship between the independent variables and the dependent variable. The dependent variable in our research is CO2 emissions and the independent variables are GDP, FDI and energy consumption.

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### 3.3 Descriptive Analysis

The first thing that we do with the data is to compute the descriptive statistics. The descriptive statistics include the mean which is the average value and the median which is the middle value. Maximum and minimum value of the time series is can also be seen. The dispersion of the time series can be measured through the standard deviation. The descriptive statistics also shows the skewness which measures the symmetry of the series. Skewness will enable us to see if the series is right tailed or left tailed.

### 3.4 Unit Root Test

Unit root test is a tool that helps to test if a series is stationary. Nason (2006) describes stationarity as a process where the statistical property of a variable does not change over time. Stationarity is an extremely important assumption when running a time series analysis. If a method that is meant for stationary series is done with non-stationary variables, misleading conclusions would be obtained. Diebold and Killian (2000) also mention that unit root makes it possible to select models that would give superior forecasts.

The model for unit root is given as below:

$$\begin{aligned} Y_t - Y_{t-1} &= \beta Y_{t-1} - Y_{t-1} + \varepsilon_t \\ \Delta Y_t &= \beta Y_{t-1} - Y_{t-1} + \varepsilon_t \\ \Delta Y_t &= (\beta - 1)Y_{t-1} + \varepsilon_t \\ \Delta Y_t &= \gamma Y_{t-1} + \varepsilon_t \end{aligned}$$

It can be explained:

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If  $\beta = 1$  then there is a unit root, which means it is a nonstationary process. If  $\beta < 1$ , there is no unit root and therefore it is a stationary process. In the case of  $\beta > 1$ , it is a situation where it is non-stationary and known as explosive process.

The model is given by

$$\Delta Y_t = \gamma Y_{t-1} + \beta_1 \Delta Y_{t-1} + \dots + \beta_k \Delta Y_{t-k} + \varepsilon_t$$

There are two tests that will be run in order to test the unit root of the variables in our analysis.

The Augmented Dickey Fuller (ADF hereafter) Test introduced by Dickey and Fuller (1981) is a better version of the original DF unit root test. This test takes into account the serial correlation problem of the data. The Phillip Perron test is a more comprehensive unit root test and it includes automatic correction that allows for auto correlated residuals.

Both tests will include the time trend and intercept in their analysis. It can be seen that time series data does have a time trend. Generally, most time series data are expected to be nonstationary. The null hypothesis for both tests would be  $H_0: \beta = 1$ ,  $Y_t$  is not stationary and has a unit root. The alternative hypothesis would be  $H_0: \beta < 1$ ,  $Y_t$  is stationary and does not have a unit root. If the p-value is higher than the significant level of 0.05, the null hypothesis would not be rejected. This would show that the series is not stationary. Otherwise, the null hypothesis is rejected and can be concluded that the series is stationary. In the event that the data is rejected at stationary, the test would be run using data that is first differenced. The results from both tests will be taken into consideration when deciding at which difference there is stationarity in the variable.



### 3.5 Lag Length Selection

When choosing the optimal lag length we have to ensure that we weigh the benefits against the cost. Adding more lags will decrease the risk of omitting significant information that is contained in the distant lags but too many lags will cause too many coefficients (Gujarati, 2004). These criteria assume that all variables will use the same lag selection. We have chosen to use information criteria such as Akaike Information Criterion (AIC hereafter) and Schwartz Information Criterion (SIC hereafter) to choose the suitable number of lags for model estimation. Gujarati (2004) also explains that AIC has a harsher penalty than  $R^2$  and SIC has a harsher penalty than the AIC. Using these criteria, we will be able to choose the appropriate lag for the model. Due to stricter penalty, the SIC criterion would underestimate the lag length to model the VECM. Therefore, we will prioritize the results from the AIC criterion.

### 3.6 Cointegration

Gujarati (2004) states the existence of a long run or equilibrium relationship can be shown through the cointegration of two or more time series. Even though there is long run equilibrium, in the short run it is possible to have a disequilibrium relationship. Unit root test cannot differentiate between a close unit root and a unit root. The pure unit root assumption is based more on convenience rather than theoretical facts (Hjalmarsson & Osterholm, 2007). In order to avoid spurious regression it is necessary to examine the cointegration of the time series. Cointegration tests for stationarity among non-stationary variables. This step is necessary to check if the model estimates a meaningful relationship. If there is no cointegration, variables will need to be used in differences. If a cointegration equation is found, then the model will be specified using the Vector Error Correction Model, otherwise a VAR model will be used.

### 3.6.1 Johansen and Juselius Test

The superior test for cointegration is Johansen's test because it is a test which has desirable statistical properties. Johansen (1988) suggests a method that is able to determine the number of cointegrating vector and estimate all the significant relationships. The Johansen and Juselius (JJ hereafter) test allows for more than one cointegration relationship to be tested. This methodology is typically used when all variables are I(1). We have already previously run unit root to confirm this relationship. However, Johansen (1995) mentions stationary variables in the system is not an issue theoretically.

The Johansen test proposes two different methods ratios that could test the significance of this correlation.

The Trace Test

$$J_{trace} = -T \sum_{i=r+1}^n \ln(1 - \hat{\lambda}_i)$$

Maximum Eigen Value Test

$$J_{max} = -T \ln(1 - \hat{\lambda}_{r+1})$$

The trace test has a null hypothesis of r cointegrating vectors and an alternative hypothesis of n cointegrating vectors. On the other hand, the Maximum Eigen Value has a null hypothesis of r cointegrating vector and alternative hypothesis of r+1 cointegrating vectors. Both tests do not follow a chi square distribution and critical values can be obtained using Johansen and Juselius (1990).

The hypotheses will include the number of cointegration expected in the model. The hypothesis will be rejected when the p-value is less than a significance level of 0.05.

Otherwise, the hypothesis will not be rejected. We will test different number of cointegrations, until the correct number of cointegration is found. This happens when we can no longer reject a hypothesis of cointegration at a given number. Lutkepohl, Saikonnen and Trenkler (2003) found that both trace test and Maximum Eigen Value are very similar and either one can be used. However, in certain situations the power of the Trace test is superior to the Maximum Eigen Value test. We will conduct both test but in the event of different results we will refer to the trace test. If cointegration is found we will proceed to use the Vector Error Correction Model.

### 3.7 Vector Error Correction Model

If a cointegration relationship is found then we can use the VECM to model our research because we know that there is long run equilibrium. If there is no cointegration then we can skip the VECM process and proceed with Granger Causality to detect the causal relationship.

$$\Delta Y_t = \alpha_1 + p_1 e_1 + \sum_{i=0}^n \beta_1 \Delta Y_{t-i} + \sum_{i=0}^n \delta_1 \Delta X_{t-i} + \sum_{i=0}^n \gamma_1 \Delta Z_{t-i}$$

$$\Delta X_t = \alpha_2 + p_2 e_{i-1} + \sum_{i=0}^n \beta_1 \Delta Y_{t-i} + \sum_{i=0}^n \delta_1 \Delta X_{t-i} + \sum_{i=0}^n \gamma_1 \Delta Z_{t-i}$$

The cointegration will show how many linear vectors there are and the number of non-stationary linearly independent combinations that would be stationary. A VECM with a negative significant coefficient would indicate that any short run fluctuations will result in stable relationship between the variables in the long run.

The results from the model would help to gain the long run coefficients for our equation. The significance of the coefficient would be tested to see if the long run relationship is a significant relationship. The significance of the coefficients can be tested through comparing the t statistics. For variable to be significant at significance

level of 0.01, the t statistics need to be greater than 4. Significance at level 0.05 can be obtained if t statistics is in between 2 and 4.

### 3.8 Ordinary Least Square

To test for short term relationship, the p-values for the coefficients are needed. This information cannot be found in the VECM. However, we can use the Ordinary Least Square (OLS hereafter) method to obtain this information.

The equation to run OLS is as follows:

$$DCO2 = \beta_0 + \beta_1 DCO2(-1) + \beta_2 DGDP(-1) + \beta_3 DFDI(-1) + \beta_4 DENERGY(-1) + \varepsilon$$

The null hypothesis is that the variables have no significant relationship. If the p-values are less than the significance level of 0.05, the null hypothesis is rejected. Otherwise, we do not reject the null hypothesis.

### 3.9 Granger Causality

Granger (1969) proposed the Granger Causality test as the most common way to test the causal relationship between two variables. The granger causality test assumes that the future cannot cause the past but the past can cause the present and the future. Another assumption of the granger causality is that a cause contains information that is unique that cannot be obtained elsewhere. Granger causality can show if a past value of the dependent is able to forecast the future value.

$X_t$  does not Granger-cause  $Y_t$  when all  $h > 0$  given that

$$F(Y_{t+h}|\Omega_t) = F(Y_{t+h}|\Omega_t - X_t)$$

$F$  is the conditional distribution and  $\Omega_t$  is all available information at time  $t$ .  $X_t$  is said to Granger-cause  $Y_t$  if  $X$  can predict the future of  $Y$ . However it is not possible to have all available information.

Therefore, the equation is adjusted to

$$F(Y_{t+h}|J_t, X_t) = F(Y_{t+h}|J_t)$$

The equation is now redefined that  $X_t$  does not Granger-cause  $Y_{t+h}$  given information  $J_t$ .

Granger (1969) describes that the two times series could be unidirectional, bidirectional or independent of each other. Granger causality can only be examined in stationary data. For data that is not stationary, it needs to be differenced before granger causality can be tested. Granger causality only allows us to detect the direction of the causality but does not show us the impact or effect of the variables.

After running VECM, we apply the Wald test to test the short run causality of the variables. The null hypothesis for the granger causality test is,  $H_0$ :  $X$  does not granger cause the dependent variable  $Y$ . The alternative hypothesis would be,  $H_1$ :  $X$  granger causes the dependent variable  $Y$ . The null hypothesis will be rejected if the p-value is less than 0.05 of the significance level. We can conclude that the dependent variable is granger caused by the independent variable. Otherwise, we do not reject the null hypothesis.

We can proceed to the long run Granger Causality test, to test for the causal relationship between the variables. The long run granger causality can be found using the VECM model. The coefficients from the error correction term can be used to detect causal

relationship. The significance of the relationship can be tested using the t statistics. If t statistics are more than 2 we can say that the relationship is significant. The  $H_0$  is that there is no granger causality running from one variable to the other. If the p-value is less than 0.05 level of significance, the null hypothesis will be rejected. Otherwise, the null hypothesis will be accepted.

## 3.10 Diagnostic Checking

### 3.10.1 Normality

We can test for the normality of the distribution using the Jarque-Bera (1987) test. Testing for normality can ensure that outliers are not included in the research sample. Osborne and Waters (2002) show that the removal of these outliers can reduce the chances of error. It will help to improve the accuracy of the estimates. The Jarque-Bera (1987) test is a Lagrange Multiplier (LM hereafter) test and it shows that it has maximum local asymptotic power. Therefore, it is one of the best tests for normality. The Jarque Bera (JB hereafter) test measures the difference in the skewness and kurtosis of the series compared to those with normal distribution.

$$Jarque\ Bera = \frac{N}{6} \left( S^2 + \frac{(K - 3)^2}{4} \right)$$

The Jarque-Bera test statistic can be compared with a chi square distribution that has 2 degrees of freedom. This test uses null hypothesis  $H_0$  is normal distribution, where skewness is zero and excess kurtosis. The alternative hypothesis is  $H_1$  is non normal distribution. If the p-value of the variable is greater than 0.05 significance level, the null hypothesis will not be rejected. Therefore it will conclude that the time series is normally distributed. Otherwise the null hypothesis will be rejected.

### 3.10.2 Autocorrelation

Autocorrelation or also known as serial correlation is a situation where the assumption for independence within the data is violated. There is similarity between the time series data and a lagged version or a future value of itself. Gujarati (2004) defines autocorrelation as a correlation ordered either in time or space between members of a series. The classic assumption is that the error term for any one observation is not relevant to the error term of any other observation. Explained symbolically, no autocorrelation would be

$$E(u_i u_j) = 0 \quad i \neq j$$

The presence of autocorrelation will complicate testing because the number of independent observations will be reduced. The presence of autocorrelation would make our model less efficient and therefore we need to test our model to ensure we're free of this problem.

We use the Breusch-Godfrey Serial Correlation LM Test to test for autocorrelation. This test is an alternative to the Durbin Watson test. The Durbin Watson test includes an area of inconclusiveness which makes the test less useful. Breusch-Godfrey takes into account that error term could be correlated over more than just one period. It is a more useful test because it is robust to the inclusion of lagged dependent variable.

Given that,

$$u_t = \rho_1 u_{t-1} + \rho_2 u_{t-2} + \dots + \rho_q u_{t-q} + \varepsilon_t$$

The null hypothesis is given by,  $H_0: \rho_1 = \rho_2 = \dots = \rho_q = 0$ . This shows that the lagged error term has no effect on the error term and therefore no autocorrelation. The alternative hypothesis is given by,  $H_1$ : at least one is  $\neq 0$ , which shows that autocorrelation occurs.

The LM test statistics is given by

$$LM = nR^2 \approx X_1^2$$

$$LM^* = \frac{n-k}{m} \frac{R^2}{1-R^2} \approx F(m, n-k)$$

The decision rule comes from comparing the Chi-square value and the significance level. If Chi-square is greater than 0.01, we do not reject  $H_0$ . This shows that there is no autocorrelation problem. Otherwise,  $H_0$  will be rejected. If there is a problem of autocorrelation, we will employ the Newey West Test to treat it.

### 3.10.3 Heteroscedasticity

Heteroscedasticity is the situation where the error terms do not have constant variance. Gujarati (2004) describes heteroscedasticity as uneven spread. If heteroscedasticity occurs, it could cause biased and misleading parameter estimates. Biased standard errors will cause incorrect conclusions about the significance of the coefficients of the model. Berry and Feldman (1985) says that slight heteroscedasticity will only have small effect on the significance of the test. However, it can lead to the findings having serious distortions if the heteroscedasticity is marked.

We used the Autoregressive Conditional Heteroscedasticity (ARCH hereafter) test to see if there was a heteroscedasticity problem in the model. ARCH test is a form of LM test that is able to assess the significance of the ARCH effects.

The model for the ARCH test is given by:

$$H_a : e_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \dots + \alpha_m e_{m-1}^2 + u_t$$



The null hypothesis is given by:

$$H_0 = \alpha_0 = \alpha_1 = \dots = \alpha_m = 0$$

The null hypothesis shows that there is no heteroscedasticity. If the p-value of the F test is more than 0.01, we do not reject  $H_0$ . Otherwise  $H_0$ , will be rejected. In a situation that  $H_0$  is rejected, we will treat heteroscedasticity by applying White Test.

### **3.10.4 Multicollinearity**

Multicollinearity occurs when independent variables have high inter correlation among each other. In other words, it happens when two or more variables are highly correlated with each other. Multicollinearity could occur when a variable is computed from other variables in the same data set. It could also occur when two variables have the same characteristics.

One way of detecting multicollinearity in the model is when the model has high  $R^2$  but low significance in the parameter (Greene, 1990). This would result in biased estimates and incorrect signs leading to inaccurate results (Kmenta, 1986). The confidence intervals would become wide and the values of the statistics would be small. It would become difficult to reject the null hypothesis and would cause biased results.

To test the existence of multicollinearity in our model we would be using the variance inflation factor (VIF hereafter) to see how much the variance is inflated. There would be an inflation of variance of the estimated coefficients if multicollinearity exists in the model.

The formula to compute VIF is given as below:

$$VIF_k = \frac{1}{1 - R_k^2}$$

The  $R_k^2$  is the value of  $R^2$  that we obtain when we regress the predictor k against all the remaining predictors. Each predictor has its own individual value for VIF.

We run the pairwise correlation coefficient analysis between the independent variables to test for multicollinearity. Hair et al. (1995) said that if the Variance Inflation Factor (VIF) is less than 10, there is no serious collinearity problem. Any VIF that is more than 10 would show serious collinearity issues in the model. Otherwise we would conclude that the variables didn't show multicollinearity problem and the model would pass the diagnostic checking. According to Gujarati and Porter (2009), the easiest way to solve the problem of multicollinearity would be to eliminate the problematic variable.

### 3.10.5 Model Specification

An error in model misspecification would mean that the current model that is being used is wrong. There are a few types of model misspecification that could occur. There could be an inclusion of unnecessary variables, deletion of importation variable or using the wrong functional form. Some of the other reasons that misspecification could occur is because of data problem. There could be missing data, outliers and non-random sampling of data.

Model specification can be tested using the Ramsay (1969) RESET test.

$$y_i = \beta_1 + \beta_2 x_{i2} + \beta_3 x_{i3} + \gamma_1 \hat{y}_i^2 + \gamma_2 \hat{y}_i^3 + \gamma_3 \hat{y}_i^4 + u_i$$

The test statistic for this test is given by

$$\frac{(R_{unrestricted}^2 - R_{restricted}^2)}{(k_{unrestricted} - k_{restricted})} \frac{(1 - R_{unrestricted}^2)}{n - k_{unrestricted}}$$

The null hypothesis is that  $\gamma_1 = \gamma_2 = \gamma_3 = 0$ . The alternative hypothesis being, either one is equal to 1. The rejection of the null hypothesis would show that one of the other variables have impact on the model. In other words, the null hypothesis would show that the model is correctly specified. The alternative hypothesis shows that the model is not correctly specified. If the p-value is less than 0.05, the null hypothesis is rejected. This would show that there is error specification. Otherwise the null hypothesis cannot be rejected.

If there is model misspecification, the RESET test doesn't give clear instructions on what should be done next. However, if there is misspecification we will add new variables or drop unnecessary ones. We would also try different functional forms to see which functional form works best.

### 3.11 Conclusion

Through studying the methodology, a deeper understanding of the concept was obtained. The methodology of our research has been discussed and justified theoretically. A framework for our research has been proposed. This methodology will be carried out in the following chapter to obtain the empirical results that will lead us to the final conclusion of our study.

## **CHAPTER 4: DATA ANALYSIS**

### **4.0 Introduction**

In Chapter 4, we going to present the analysed data extracted from World Bank. The data collected has a total of 41 observations, from year 1971 to 2011.

By using Eviews 7.2, the data was analysed by using several tests such as ADF Unit Root Test, Phillips-Perron (PP hereafter) Unit Root Test, Johansen Cointegration Test, VECM and Granger Causality Test. Also, diagnostic checking has been run to make sure the robustness of OLS regression.

ADF Unit Root Test and PP Unit Root Test is used to test a time series variable, to see whether it is stationary or non-stationary by using an autoregressive model. Johansen Cointegration Test is used to test the cointegration equation in the model. After that, VECM will be used to investigate the long run and short run relationships between variables in the model. Besides, Granger Causality Test is run to identify the direction or bidirection relationship between variables. Lastly, diagnostic checking is run to ensure the robustness of OLS regression.

## 4.1 ADF and PP Unit root test

Table 4.1: Stationary test for all variables – I (0)

Details: in Level Form

Variables	Constant with trend		Constant without Trend	
	ADF	PP	ADF	PP
CO2	-2.516357 (0.3190)	-2.516357 (0.3190)	0.273322 (0.9739)	0.390187 (0.9801)
GDP	-1.868772 (0.6519)	-1.846284 (0.6632)	0.909486 (0.9947)	0.909486 (0.9947)
EG	-2.941885 (0.1609)	-2.860945 (0.1855)	0.289521 (0.9748)	0.834619 (0.9935)
FDI	-3.162125 (0.1066)	-3.162125 (0.1066)	-3.204159 (0.0271)	-3.204159 (0.0271)

Note: \*\* indicates statistically significant at 0.05 and \* indicates statistically significant at 0.1

$H_0$ : There is unit root in variable.

$H_1$ : There is no unit root in variable.

In table 4.1, we show the result of both ADF test and PP test result in level form. We tested all variables with trend and without for both ADF and PP test. According to table 4.1, all variables have unit root in with trend and without trend after tested by ADF and

PP test. Our aim is to achieve stationary status for all variables at all significant levels. Therefore we continued ADF test and PP test with first difference.

Table 4.2: Stationary test for all variables- I (1)

Details: First difference- I (1)

Variables	Constant with trend		Constant without Trend	
	ADF	PP	ADF	PP
CO2	7.052988** (0.0000)	7.043577** (0.0000)	6.963010** (0.0000)	6.961393** (0.0000)
GDP	6.049900** (0.0001)	6.049900** (0.0001)	5.902846** (0.0000)	5.903728** (0.0000)
EG	6.246564** (0.0000)	8.105719** (0.0000)	6.760324** (0.0000)	7.260444** (0.0000)
FDI	7.025635** (0.0000)	7.400414** (0.0000)	7.121481** (0.0000)	7.515040** (0.0000)

Note: \*\* indicates statistically significant at 0.05 and \* indicates statistically significant at 0.1

$H_0$ : There is unit root in variable.

$H_1$ : There is no unit root in variable.

Table 4.2 shows the unit root test result in first difference for all variables. According to the result, all variables are stationary at first differencing with trend and without trend for both ADF and PP test in all 5%, and 10% significant. According to Mahadeva and Robinson (2004), they stated that the ADF test is sensitive to structural breaks and poor small sample power which often result a unit root conclusion. Also,

they proved that PP test works better in time series data. In addition, the variables will no longer have trend after first differencing (Mahadeva & Robinson, 2004). From table 4.1.2, the results show that all variables do not have unit root at all significant levels which are 10% and 5% for ADF and PP test. In another words, all variables are stationary at first difference. Therefore, we can continue Johansen Cointegration Test.

## 4.2 Lag Length Selection

Table 4.3: Lag length Selection

Lag	AIC	SC
0	-1.674022	-1.499869
1	-6.901643*	-6.030877*
2	-6.499147	-4.931768
3	-6.064465	-3.800473
4	-5.925150	-2.964544

\*Represent number of lag selected by criteria

AIC: Akaike Information Criterion

SIC: Schwarz Information Criterion

According to table 4.3, it shows that the lag length selection criteria by SIC and AIC are both lag order 1. As a result, lag 1 is chosen in model.

### 4.3 Johansen Cointegration Test

Table 4.4: Johansen Cointegration Test Result

Sample (adjusted): 1973 2011

Included observations: 39 after adjustments

Trend assumption: Linear deterministic trend

Series: LGCO2 LGENERGY LGFDI LGGDP

Lags interval (in first differences): 1 to 1

Hypothesized No. of Cointegrating Equation	Trace Test (p-value)
0	0.0248**
1	<b>0.1785</b>

Note: \*\* indicates statistically significant at 0.05 and \* indicates statistically significant at 0.1

$H_0$ : There is no cointegrating equation.

$H_1$ : There is cointegrating equation.

According to table 4.4, the first hypothesis having p-value 0.0248 for Trace test which is lower than significant level 0.1 and 0.05.  $H_0$  is rejected.

In addition, the Trace test has a p-value of 0.1785 which is higher than significant level 0.1 and 0.05. Thus,  $H_0$  cannot be rejected. From the result, we can conclude that there is at least one cointegration equation that exists in our model. Since we have cointegration equation in our model, we continue with our estimation of our variables with VECM.



## 4.4 Vector Error Correction Model

Table 4.5: Long run relationship from VECM model

Variable	Coefficient	t-statistics
GDP(-1)	-0.083832**	-4.99165
EG(-1)	0.172296**	5.02177
FDI(-1)	4.245122**	1.37107
R-Square	0.3139	
Adjusted R- Squared	0.2100	
Prob (F-statistics)	0.0236	

Note: \*\* indicates statistically significant at 0.05 and \* indicates statistically significant at 0.1

$$D(\text{CO}_2) = 24.02587 - 0.083832\text{GDP}(-1) + 0.172296\text{EG}(-1) + 4.245122\text{FDI}(-1)$$

$$\quad \quad \quad [-4.99165]** \quad [5.02177]** \quad [3.09622]**$$

Where:

$\text{CO}_2(-1)$  = first different of  $\text{CO}_2$  emission in Malaysia

$\text{GDP}(-1)$  = first different of Malaysia's GDP

$\text{EG}(-1)$  = first different of Energy Consumption in Malaysia

$\text{FDI}(-1)$  = first different of FDI in Malaysia

[ ] represents t-stat

Table 4.5 shows the long run relationship among CO2 emission, GDP, Energy Consumption, and FDI. Equation above shows three significant independent variables in explaining CO2 emission in the long run relationship.

According to table 4.5, GDP has t-stat of -4.99165. It is significant at 0.05 level in long run. Thus, we do not reject  $H_0$  and conclude that GDP has significant negative relationship with CO2.

In addition, Energy Consumption has t-stat of 5.02177. It is significant at 0.05 level in long run. Thus, we do not reject  $H_0$  and conclude that Energy Consumption has significant positive relationship with CO2.

In the other hand, FDI t-stat is 3.09622. It is significant at 0.05 level in long run. Thus, we do not reject  $H_0$  and conclude that FDI has significant positive relationship with CO2.

As a result, an increase in 1 dollar of GDP will cause CO2 to decrease by 0.0838 metric tons in long run. Besides, an increase in 1kg of Energy will cause CO2 to increase by 0.1723 metric tons in long run. Nonetheless, an increase in 1% of FDI will cause CO2 to increase by 4.2451 metric tons in long run.

The R-square of this model is 0.3139, which means that the GDP, Energy Consumption and FDI explained 31.39% of variation in CO2 while remaining 66.61% of the variation is not explained. Therefore, we conclude that there are missing variables that should include in the model.

Table 4.6: Short run relationship from VECM model

Table 4.4.2 Short run relationship from VECM model

Dependent Variable: D(CO2)  
 Method: Least Squares  
 Date: 03/10/16 Time: 22:20  
 Sample (adjusted): 1973 2011  
 Included observations: 39 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(CO2(-1))	-0.166565	0.193696	-0.859929	0.3960
D(GDP(-1))	0.001630	0.000561	2.907057	<b>0.0065**</b>
D(EG(-1))	-0.002834	0.000917	-3.091066	<b>0.0040**</b>
D(FDI(-1))	0.001596	0.037350	0.042720	0.9662
C	0.140393	0.074226	1.891415	0.0674
Y	1.000000	0.471229	2.122110	<b>0.0414**</b>
R-squared	0.313927	F- statistic		3.019972
Adjusted R-squared	0.209977	Prob (F-statistic)		0.023649

Note: \*\* indicates statistically significant at 0.05 and \* indicates statistically significant at 0.1

According to table 4.4.2, short run equation of our model shows as below;

$$D(\text{CO}_2) = -0.166565D(\text{CO}_2(-1)) + 0.001630D(\text{GDP}(-1)) - 0.002834D(\text{EG}(-1)) +$$

$$\quad \quad \quad [2.9070^{**}] \quad \quad \quad [-3.0911^{**}]$$

$$0.0015956D(\text{FDI}(-1)) + 0.140393 + 0.999Y$$

According to Table 4.6, short run relationship among CO2 emission, GDP, Energy Consumption, and FDI are investigated. The equation above shows two significant independent variables in explaining CO2 in short run relationship, which are GDP and Energy Consumption. However, result shows there is no significant relationship between FDI and CO2.

According to Table 4.6, GDP has t-stat of 2.9070. It is significant at 0.05 level in short run. Thus, we do not reject  $H_0$  and conclude that GDP has significant positive relationship with CO2.

In addition, Energy Consumption has t-stat of -3.0911. It is significant at 0.05 level in short run. Thus, we do not reject  $H_0$  and conclude that Energy Consumption has significant negative relationship with CO<sub>2</sub>.

In the other hand, FDI t-stat is 0.0427. It is not significant at 0.05 level in short run. Thus, we reject  $H_0$  and conclude that FDI has no significant positive relationship with CO<sub>2</sub>.

## **4.5 Diagnostic checking**

### **4.5.1 Descriptive Analysis (Normality)**

To make sure there is no missing data, descriptive analysis has been done. Also, the normally distribution of variables also can get from Descriptive Analysis.

Table 4.7: Descriptive analysis

Sample 1971-2011

	CO2	GDP	EG	FDI
Mean	4.075045	3677.444	1529.457	3.855221
Median	3.666052	3355.617	1458.508	3.769208
Maximum	7.986951	6584.313	2818.864	8.760533
Minimum	1.491451	1427.102	520.1404	0.056692
Std. Dev.	2.172890	1570.849	755.2538	1.853393
Skewness	0.340197	0.283647	0.283766	0.510615
Kurtosis	1.633638	1.749396	1.708358	3.429784
Jarque-Bera	3.980213	3.221633	3.400319	2.097190
Probability	0.136681	0.199725	0.182654	0.350430
Sum	167.0768	150775.2	62707.72	158.0641
Sum Sq. Dev.	188.8580	98702637	22816330	137.4026
Observations	41	41	41	41

Table 4.7 showed the descriptive analysis result on four logged variables. All logged variables have 41 observations from year 1971 to 2011. This indicates that there is no missing data for variables.

For information, throughout the whole research report, CO2 represents CO2 emissions (metric tons per capita), GDP represent GDP per capita, constant 2005 US\$, Energy Consumption represent energy use, kg of oil equivalent per capita, while FDI represent FDI, net inflows (% of GDP).

The JB test statistic of CO2 is 3.9802, which is greater than p-value 0.1369, this means that we do not reject the null hypothesis and CO2 is normally distributed. The JB TEST statistic of GDP is 3.2216, which is greater than p-value 0.1997, this means that we do not reject the null hypothesis and GDP is normally distributed. The JB test statistic of Energy Consumption is 3.4003, which is greater than p-value 0.1827, this means that we do not reject the null hypothesis and EG is normally distributed. The JB test statistic of FDI is 2.0972, which is greater than p-value 0.3504, this means that we do not reject the null hypothesis and FDI is normally distributed. In nutshell, all four variables have 41 observation and all are normally distribution.

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Table 4.8: Diagnostic Checking

Diagnostic Checking	
Tests	p-value
VEC Residual Serial Correlation LM Test	0.2475
Heteroscedasticity Test	0.2999

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### 4.5.2 Autocorrelation

$H_0$ : There is no autocorrelation problem.

$H_1$ : There is autocorrelation problem.

By using Breusch-Godfrey Serial Correlation LM Test, we obtained the result of p-value 0.2475, which is higher than the significant level of 0.1 and 0.05. Therefore, we will not reject  $H_0$ . This indicates that there is no autocorrelation problem in the model.

### 4.5.3 Heteroscedasticity

$H_0$ : There is no heteroscedasticity problem.

$H_1$ : There is heteroscedasticity equation.

By using Heteroscedasticity Test, we obtained the result of p-value 0.2999, which is higher than the significant level of 0.1 and 0.05. Therefore, we will not reject  $H_0$ . This indicates that there is no heteroscedasticity problem in the model.

#### 4.5.4 Multicollinearity

Our model has a modest R-square of 0.313927, and significant F-test statistics (P-value: 0.023649). And one of our independent variable is not significant as its p-value is higher than 0.05 significant level. The variable which is not significant is FDI because it has a p-value of 0.9662. Thus we suspect our model of potentially suffering from multicollinearity. Next we proceed to Variance Inflation Factor (VIF) to identify the degree of correlation between variables.

The formula of computing VIF is as follows:

$$VIF = \frac{1}{(1 - r^2)}$$

Given:

$VIF$  = Variance Inflation Factor

$r^2$  = R-square between independent variables

Table 4.9: VIF for the independent variables based on above formula

Variables	R <sup>2</sup>	VIF	Low/Moderate/High
GDP	0.308402	[1/(1-0.308402)] = 1.4459	Low
EG	0.224364	[1/(1-0.224364)] = 1.2892	Low
FDI	0.240714	[1/(1-0.240714)] = 1.3170	Low

Based on the table above, it is obvious that all independent variables have less serious multicollinearity problem, as all VIF values are less than 10. Hence, we conclude that there is no serious multicollinearity problem among the independent variables and the model will not produce misleading and confusing results.

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### 4.5.5 Ramsey's RESET Test

Table 4.10: Ramsey's RESET Test

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F-statistic	0.97094
Prob.F(1,32)	0.3318
Log likelihood ratio	1.165746

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$H_0$ : Model specification is correct.

$H_1$ : Model specification is incorrect.

By using Ramsey's reset test, we get the result of p-value 0.3318, which is higher than the significant level of 0.1 and 0.05. Therefore, we do not reject  $H_0$ . This indicates that our model is correctly specified in terms of adopting the right functional form.



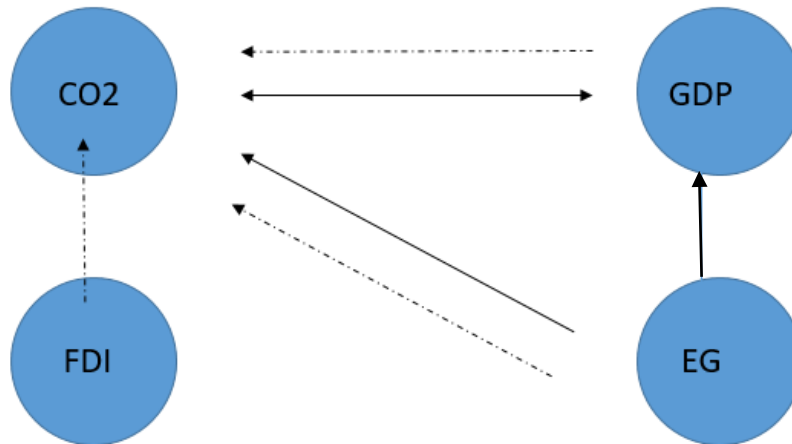
## 4.6 Granger Causality Test Based on VECM

Table 4.11: Granger Causality Test

Independent \ Dependent	F-Statistics				t-statistic
	D(CO2)	D(GDP)	D(EG)	D(FDI)	ECT
D(CO2)	-	3.8075*	0.0724	0.6851	0.00977
		[0.0510]	[0.7878]	[0.4078]	
D(GDP)	8.4509**	-	1.0559	1.2787	3.122486
	[0.0036]		[0.3041]	[0.2581]	
D(EG)	9.5547**	13.799**	-	1.6995	-1.338079
	[0.0020]	[0.0002]		[0.1923]	
D(FDI)	0.0018	0.1977	2.5311	-	-0.020655
	[0.9659]	[0.6566]	[0.1116]		

Notes: \*\* indicates statistically significant at 0.05 and \* indicates statistically significant at 0.1

Figure 4.1 Graphical summary of Granger causality test



X  $\longrightarrow$  Y shows that X granger cause Y in short run

X  $\dashrightarrow$  Y shows that X granger cause Y in long run

X  $\longleftrightarrow$  Y shows that X and Y granger causes each other

Table 4.11 shows the result of Granger Causality Test which represents the unidirectional and bidirectional relationship between time series. According to table 4.11, we can conclude that there is short run bidirectional relationship between GDP and CO2. In addition, Energy Consumption has unidirectional relationship to CO2 and GDP. Also, results show that the FDI, GDP and Energy Consumption having a long run unidirectional relationship to CO2.

## 4.7 Conclusion

In Chapter 4, we interpret the result of six tests. They are ADF & PP Unit Root Test, Johansen Cointegration Test, VECM, diagnostic checking and Granger Causality Test. ADF & PP unit root test's results show that our data is not stationary at level form but it is stationary at first difference. Next test is Johansen Cointegration Test. According to the result, there is one cointegration equation in model, thus we continued the VECM model to investigate the long run relationship between variables, and the results show that Energy Consumption and FDI have positive relationship with CO<sub>2</sub> while GDP has a negative relationship with CO<sub>2</sub>. Nonetheless, we also tested for short run relationship between variables, results show that Energy Consumption has a negative relationship with CO<sub>2</sub> in short run. While GDP and FDI have a positive relationship with CO<sub>2</sub> in short run. Normality, VEC Residual Serial Correlation LM Test, Heteroscedasticity Test, Multicollinearity VIF test and Ramsey's reset test was also conducted and we concluded that our model is free from heteroscedasticity, autocorrelation and multi-correlation problem and the model specification is correct after the diagnostic checking. Lastly, the Granger Causality Test shows that there is short run bidirectional relationship between GDP and CO<sub>2</sub>. In addition, Energy Consumption has short run unidirectional relationship with CO<sub>2</sub> and GDP. While for the long run Granger, results show the FDI, GDP and Energy Consumption having a long run unidirectional relationship to CO<sub>2</sub>.

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## **CHAPTER 5: DISCUSSION, CONCLUSION AND IMPLICATIONS**

### **5.0 Introduction**

As we come to the final part of our research we will summarize the entirety of our research and draw the final conclusions from the results that have been found. There will be a summary of the results from the statistical analysis that was conducted earlier. This will be followed by a discussion on the major findings that will authenticate our study which is in line with our objectives and hypotheses. We will then look at the implication of our research and how it can be used to tackle real-world problems through feasible policies. All researches are bound to have limitations. We will also include a discussion on the shortcomings that was found and the barriers that were faced when conducting this research. Lastly, recommendations to overcome these problems will be included for the reference of future researchers.

### **5.1 Summary of Statistical Analyses**

The main objective of this research paper is to examine the relationship and directional causality in the short run and long run of FDI, GDP and Energy Consumption on CO<sub>2</sub> emission and to examine the validity of PHH in Malaysia from the year 1972 to 2011.

To make sure our model is stationary; ADF and PP test are conducted. We found out that all variables are stationary at first difference. Hence, we continue Johansen Cointegration Test to find out if there is cointegration in our model; results show that there is at least one cointegration in our model. In other words, the result shows that

there is long run equilibrium relationship in our model and VECM will be conducted instead of VAR which is used to test short run relationship.

Before we continue VECM, we run the lag length selection AIC and SIC to determine the lag that we should include in our model which is used in VECM. We emphasize on AIC to avoid the underestimation of SIC. Result shows that we should include one lag number in our model. Next, we continue VECM to examine our objective which is to examine short run and long run relationships among FDI, GDP and Energy Consumption on the CO<sub>2</sub> emission. Short run results show two significant independent variables in explaining CO<sub>2</sub> emission, which are GDP and Energy Consumption. However, result shows there is no significant relationship between FDI and CO<sub>2</sub> in short run. While in long run, our result shows that all of our variables which are FDI, CO<sub>2</sub>, GDP and Energy Consumption are significant at significant level of 5% and 10%. In order to make sure our model is free from econometrical problems, LM and Heteroscedasticity test, Multicollinearity VIF test and Normality and Ramsey's reset test are conducted. The result shows that our model is free from autocorrelation, heteroscedasticity, and multicorrelation problems and our model specification is correct. Nonetheless, to achieve another objective which is to examine the causal relationship of FDI, GDP and Energy Consumption on CO<sub>2</sub> emission, Granger causality test is conducted. Results show that there are both unidirectional and bidirectional relationships appearing in our model. Also, there are long run relationships amongst the variables.

## **5.2 Major Findings**

We have conducted this research mainly to study the PHH hypothesis in Malaysia. Our main intention is to see how FDI affects the CO<sub>2</sub> emissions. At the same time, we also study the effects of GDP and energy Consumption. We continue to discuss the important results that we have obtained from this study. We have also observed how our results are similar with our hypotheses of our research which was stated in Chapter

1 of this research.

In the short run, FDI has a positive relationship with CO<sub>2</sub> emissions. This is consistent with our hypothesis. FDI has a strong adverse relationship with CO<sub>2</sub> emissions. Even in the short run, the effects on the environment can be noticed. Even in the long run, FDI is found to have a positive relationship with CO<sub>2</sub> emissions in Malaysia. This is consistent with our hypothesis in previous chapter and is supported by Guan, Peters, Weber and Hubacek (2009) where they state that China's CO<sub>2</sub> emission increased 5039 million tons from year 1980 to 2007 since China open their economy. According to previous researchers, they have concluded that FDI has a positive relationship on CO<sub>2</sub> emission. For example Ren, Yuan, Ma and Chen (2014), they found out a positive relationship between FDI and CO<sub>2</sub> emission in China. While Smarzynska and Wei (2001) analysed 24 economies in Europe and concluded that CO<sub>2</sub> emission increase when there is FDI inflow. Nonetheless, Pao and Tsai (2011) also support this statement after their research on the dynamic relationships between CO<sub>2</sub> emission, FDI, Energy Consumption and economic growth for BRIC. Lastly, research proved that FDI inflow does degrade the environmental condition. In other word it increases the emission of CO<sub>2</sub> in 44 developing countries (Talukdar & Meisner, 2001). Not only that, our result is also supported by the research done in the case of Malaysia by Lau, Chong, and Eng (2014) where their research shows a positive relationship between FDI and CO<sub>2</sub> emission from the year 1970 to 2008.

One of our hypothesis for this research is that the PHH is valid in Malaysia. Our hypothesis is supported as we can see that FDI has a positive relationship with CO<sub>2</sub> emissions. This shows that the increase in the inflow of FDI will increase CO<sub>2</sub> emissions. We can see that the investment that is brought in to Malaysia is "dirty" investments that increase the pollution level in the country. There are many researchers who have research that support this hypothesis and are mostly growing economies that have valid PHH theory. It shows that the environmental stringency in Malaysia is low. A high number of FDI that comes into the country is from industries that pollute the environmental quality.

Energy Consumption in the short run showed negative relationship. This is inconsistent with our hypothesis. It is because that the short run the effects of the increase in energy Consumption is not detected by the CO<sub>2</sub> emission. However, Energy Consumption was found to have a positive relationship with CO<sub>2</sub> emission in the long run which is consistence with our hypothesis in our previous chapter. In other words, when Energy Consumption increases, CO<sub>2</sub> emissions will increase in the long run which is support by Saboori, Sapri and Baba (2014) where they state that there is a positive relationship between CO<sub>2</sub>, GDP and Energy Consumption. Nonetheless, the author also stated that when there is Energy Consumption, there is CO<sub>2</sub> emission. According to previous researchers, they have concluded that Energy Consumption has a positive relationship on CO<sub>2</sub> emission. For example Alkathlan and Javid (2013), their research result shows a positive relationship between CO<sub>2</sub> emission and Energy Consumption. While Al-Mulali (2012) studied a large time series of seven regions by using FMOLS method and concluded that there is a long run relationship between urbanization, Energy Consumption and CO<sub>2</sub> emission. Nonetheless, the statement was also supported by research from China studying relationship between economic growth, Energy Consumption and CO<sub>2</sub> emission (Wang, Li, Fang, & Zhou, 2015). In the case of Malaysia, researchers also support the above statement where they found a positive relationship between Energy Consumption and CO<sub>2</sub> emission (Ang, 2008; Hossain, 2011; and Mugableh, 2013).

We have found that there is a positive relationship between GDP and CO<sub>2</sub> emissions in the short run. Our hypothesis that expected a positive short run relationship is accepted. Hamdi (2016) has also found the same results in his investigation of Tunisia and Morocco. He found that in the initial stages, the increase in economic growth will increase the emissions of CO<sub>2</sub>. While in the short run, economic growth increases the emissions, in the long run, economic growth reduces the CO<sub>2</sub> emissions. We have found that in the long run there is a significant negative relationship between GDP and CO<sub>2</sub> emissions. The results however, are not consistent with our expected hypotheses. We expected the GDP in the long run to have a positive relationship. We have, instead, found that there is a negative relationship between GDP and CO<sub>2</sub>. This shows that GDP

initially increases the emissions of CO<sub>2</sub> emissions but over time, the CO<sub>2</sub> emissions are decreased. This result is consistent with the findings of Lindmark (2002) who studied Sweden and Aldy (2005) who studied the USA. Narayan and Narayan (2010) also found similar results in a study of Middle Eastern and South Asia panels. Jalil and Mahmud (2009) found consistent results in China while Coondoo and Dinda (2008) found similar results in China. We can see that our results are consistent with multiple researchers around the world. Moreover in the case of Malaysia, the result is supported by the study of Saboori, Sulaiman, and Mohd (2012) where their result shows a negative relationship between GDP and CO<sub>2</sub>. Over time, economic growth will be adjusted until it no longer affects CO<sub>2</sub> emissions adversely.

The findings from the short Granger Causality test shows that there is short run bidirectional causality between economic growth and CO<sub>2</sub> emissions in Malaysia. We did expect to find short run causality and this is consistent with our hypothesis. This is consistent with the research of Shahbaz et al. (2016) in Malaysia. Omri et al. (2014) also found bidirectional causality for CO<sub>2</sub> and GDP in the sub-Saharan panel. Chandran and Tang (2013) have also researched the causality between CO<sub>2</sub> emissions and GDP in ASEAN countries and found the same results for Malaysia, Thailand and Indonesia. The results from Pao & Tsai (2011) and Omri (2013) are also consistent with this finding. This shows that the effects of the variables are both ways. While the economic growth causes CO<sub>2</sub> emissions to increase, CO<sub>2</sub> emissions in turn also cause an increase in economic growth. This shows that a feedback effect exists between the two variables.

Our hypothesis that expected long run Granger causality between the variables is accepted based on the results we have found. There were two unidirectional relationships in the short run for Granger causality. There is a Granger causality running from Energy Consumption to economic growth. Chandran and Tang (2013) found that there was short run Granger causality from Energy Consumption to GDP in Indonesia and Singapore. The research of Mugabeh (2013) is also consistent with this finding. This shows that efforts to develop the energy sector would in turn increase the



economic development of Malaysia. We have also found that in the short run there is unidirectional causality relationship running from Energy Consumption to CO<sub>2</sub> emissions. This result is similar to the research of Pao and Tsai (2011) in BRIC countries. This shows that in Malaysia, the change in Energy Consumption will cause CO<sub>2</sub> to be affected in the short run. While developing our energy sector will increase economic growth, it will in turn adversely affect the environmental health of the country.

Moreover, we have found a long run unidirectional in our research where FDI, GDP and Energy Consumption has unidirectional relationship towards CO<sub>2</sub> emission. This research is aligned with the study by Al-Mulali and Tang (2013) where their research found a long run unidirectional Granger causality from FDI, GDP and Energy Consumption to the CO<sub>2</sub> emission in the case of GCC countries from the time frame of 1980 to 2009. Moreover, this is also aligned with the research done by Chandran and Tang (2013) with their case of ASEAN-5 countries where they have found the long run unidirectional causality of FDI, GDP and Energy Consumption to CO<sub>2</sub> emission.

## **5.3 Implication of the Study**

### **5.3.1 Policy Implication**

In our studies, we have found out that there is a positive relationship between FDI and CO<sub>2</sub> in which PHH exists in Malaysia. With that being said, we would like to suggest that the government could impose an environmental policy that provides incentive for the foreign investors or Multinational Company (MNC thereafter) to invest on green technology or pollutant friendly projects and if the foreign investor were to go against it, they will be put to justice. The environmental regulation can charge a certain carbon tax to the company that pollutes over the suggested amount that otherwise will be dangerous to the public and environment as a whole. With the support from other

researcher, they have also suggested that countries which suffers from a positive relationship between FDI and CO<sub>2</sub> to impose a carbon emission tax to the pollution heavy MNCs (Narayan & Narayan, 2010; Pao & Tsai, 2010). Moreover, since our findings shows that the FDI has a long run causality in affecting CO<sub>2</sub>, we would suggest that the policy makers should give a certain incentive for the foreign investors to reduce their pollution. It is because FDI inflow is important for the economy to grow thus policy makers should increasingly induce and sustain FDI in the long run but with the corrective measures that will not allow the foreign investor to pollute.

Besides that, short run positive bidirectional causality between GDP and CO<sub>2</sub> emission in Malaysia shows that the increase in growth of the economy will cause a harm towards the quality of the environment. Thus a strong effort by the government to encourage industries to implement a cleaner mechanism of development and technologies that are environmentally friendly. Moreover with the long run negative relationship between GDP and CO<sub>2</sub>, it shows that the country is able to reduce the CO<sub>2</sub> emission as its economy is growing. Thus, Malaysia have to continue to positively stimulate environmental awareness to the MNCs and to the locals of Malaysia to further reduce the CO<sub>2</sub> emission.

Moreover, the negative relationship between Energy consumption and CO<sub>2</sub> in Malaysia indicates that the CO<sub>2</sub> emission will decrease when the consumption for energy increases. With that, we would suggest that the companies in Malaysia to pursue into investments of development that encourages the consumption of renewable energy in an efficient manner. This will diminish the dependent of the consumption of non-renewable energy and upsurges the part by the renewable energy that can lower the pollution (Al-Mulali, Saboori, Ozturk, 2015). Besides that, the policy makers should strengthen the environmental rules that will promote the foreign investors to use renewable or self-sustaining energy. Since the energy consumption data that we have used is based on aggregated data, both renewable and non-renewable energy will eventually increase the CO<sub>2</sub> emission in the long run and thus justifies our reason to change the consumption of non-renewable energy and focus on renewable energy for a better and sustainable Malaysia. If not, the pollution level in the country will be

worsen at a worsened condition as the income status grows since Malaysia is still in a developing middle income country.

## **5.4 Limitations of the Study and Recommendation for Future Research**

We have encountered two limitations during our research. First is the usage of aggregated data in our research and second is the lack of availability to the disaggregated data in the case of Malaysia. Although we have met our objective of our research with the usage of the currently available data, the accessibility to the disaggregated data may produce more specific result and thus, this will be a recommendation for the future researchers to validate the existence of the PHH hypothesis in a much detailed scale of data where it will still depends on the objective of their research which will be explained in the following paragraph.

Aggregated data shows a mixture of the same classes or genre of primary data where normally is within the same branch of a chain of command with the purpose of expressing the data at a summary level (United Nations Glossary of Classification Terms, n.d.). By using the aggregated data, the result may produce a bias outcome. In this case, the FDI inflow data explores the relationship of CO<sub>2</sub> between different industries or sectors of the FDI in Malaysia as a whole. The FDI inflow may consists of both pollution concentrated foreign investors and also non-polluting concentrated foreign investor where both will contribute to different level of the CO<sub>2</sub> emission level. With this, we will recommend the future researchers to examine the relationship between the FDI inflow and CO<sub>2</sub> emission in a disaggregated data and may determine which sector is the most significant in causing the CO<sub>2</sub> emission to increase with subject to accessibility of the data and their objective of research. Future researcher may also test out whether the foreign or the local firms are the ones that contributes most to the pollution level in Malaysia. Moreover, the energy consumption data that

we used in our research consist of a non-renewable energy. With reference to Bowden and Payne (2010), the relationship among CO<sub>2</sub> emission and renewable energy showed a positive result whereas for the relationship of CO<sub>2</sub> emission and non-renewable energy produces a negative result. Thus, the future researchers would consider alternative types of energy which may include non-renewable or renewable energy to be used in their research with the subject to availability of data and their objective of research. In addition, the future researchers' may consider to disaggregate the energy consumption into diverse types of specific fuels for instance biomass, coals or natural gas. Lastly, future researchers may study on the wider sources of environmental pollutants from the greenhouse gasses which includes methane, nitrous oxide and fluorinated gasses.

## **5.5 Conclusion**

With that, our research has met its objectives by being able to prove the existence of the PHH in Malaysia. Our research also found long run unidirectional causality from FDI, GDP and Energy Consumption to CO<sub>2</sub> emission and short run unidirectional causality from Energy Consumption to CO<sub>2</sub> emission and GDP and also bidirectional causality from CO<sub>2</sub> to GDP. We have also found a positive short run relationship between CO<sub>2</sub> and GDP, CO<sub>2</sub> and FDI whereas a negative short run relationship among CO<sub>2</sub> and energy. We have also found out that the relationship in the long run for CO<sub>2</sub> with FDI is positive thus proving the existence of PHH hypothesis and CO<sub>2</sub> with Energy Consumption producing a positive long run relationship whereas a negative long run relationship exists for CO<sub>2</sub> with GDP. A brief summary is as below:

- 1) Proved the existence of PHH hypothesis.
- 2) Long run unidirectional causality from FDI, GDP and Energy Consumption to CO<sub>2</sub> emission.
- 3) Short run unidirectional causality from Energy Consumption to CO<sub>2</sub> emission and GDP.

- 4) Short run bidirectional causality between CO2 and GDP.
- 5) Long run positive relationship between CO2 emission and FDI.
- 6) Long run positive relationship between CO2 emission and Energy Consumption.
- 7) Long run negative relationship between CO2 emission and GDP.
- 8) Short run positive relationship between CO2 and FDI.
- 9) Short run positive relationship between CO2 and GDP.
- 10) Short run positive relationship between CO2 and Energy Consumption.

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