AN ANALYSIS ON FACTORS THAT CONTRIBUTED TO ENVIRONMENTAL DEGRADATION IN SELECTED ASEAN-5 COUNTRIES

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BY

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DECLARATION

We hereby declare that:

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

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

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

(4) The word count of this research report is 10804.

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey Fuller
ARDL	Autoregressive Distributed Lag
ASEAN	Association of Southeast Asian Nations
CO_2	Carbon Dioxide
DCTPS	Domestic Credit to Private Sector
DOLS	Dynamic Ordinary Least Squares
ECM	Error Correction Method
EKC	Environmental Kuznets Curve
FDI	Foreign Direct Investment
FEM	Fixed Effects Model
FMOLS	Fully Modified Least Squares
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GLS	Generalized Least Squares
GMM	Generalized Method of Moments
IMF	International Monetary Fund
KC	Kuznets Curve
LLC	Levin-Lin-Chu
OECD	Organisation for Economic Co-operation and Development

OLS	Ordinary Least Squares
PMG	Pooled Mean Group
POLS	Pooled Ordinary Least Squares
REM	Random Effects Model
TOL	Tolerance
VECM	Vector Error Correction Model
VIF	Variance Inflation Factor
WDI	World Development Indicators

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PREFACE

Economy development is important for a country to enhance its reputation and strengthen its home currency and competitiveness. As a result, there is always a huge amount of deforestation activities happened around the world for economy development purpose and result in a high volume of annual CO_2 that released by each country. However, the high volume of CO_2 emissions had brought some negative impacts such as worsen the environment quality, affect the health condition of the society, global warming, and others. The impacts that generated by CO_2 emissions had also brought negative effect to the countries around the world. For example, Australia faced losses from bushfire that result from high global temperature that caused by high CO_2 emissions.

Therefore, there are more and more countries implement and establish strategies that would help to control and reduced the CO_2 emissions. Unfortunately, most of the countries do not have a clear vision regarding the factors that contributed to CO_2 emissions and might implement the wrong and inaccurate strategy and thus affect the efficiency and effectiveness in reducing the CO_2 emissions. Therefore, this inspired us to conduct research on factors that contributed to environmental degradation in selected ASEAN-5 countries to increase society's awareness, attention, and enthusiasm of finding the solution to address the current environmental issue. Methodology such as Levin-Lin-Chu Unit Root Tests, Hausman Test, Breusch-Pagan Lagrange Multiplier Test, and others had been applied in the research.

ABSTRACT

Carbon Dioxide (CO_2) emissions were one of the major contributors to environmental degradation. This research aims to investigate the relationship between CO_2 emissions and combination of four independent variables which are gross domestic product, foreign direct investment inflows, domestic credit to private sector and individuals using the internet. This scope of research includes Indonesia, Malaysia, Thailand, Philippines, and Vietnam and the sample period started from year 2004 to 2017. The techniques used to estimate our econometric model include Pooled Ordinary Least Squares, Fixed Effects Model and Random Effects Model which all will be measured using EViews. The empirical results show that gross domestic product, domestic credit to private sector and individuals using the internet are positive and significantly related with CO_2 emissions. In other words, the economic growth and financial development of a country will stimulate the economic activity of a nation and further lead to CO_2 emissions. The used of internet in economic activities will also contributed to CO_2 emissions. Additionally, the result also discovers that there is an insignificant relationship between CO_2 emissions and foreign direct investment inflows. This is attributable to the flows of investment to ASEAN countries that majority goes to services sector that contribute less CO_2 emissions as compared to manufacturing sector. The result does not support the validity of Environmental Kuznets Curve Hypothesis and Pollution Haven Hypothesis in selected ASEAN-5 countries. The research is useful for government and policymaker in implementing their policies as to reduce the emissions of greenhouse gases and slow down the environmental degradation.

CHAPTER 1: RESEARCH OVERVIEW

1.0 Introduction

Chapter 1 introduced the background and issue arise from environmental degradation. This chapter also discusses the research objectives, significance and organization of this study.

1.1 Research Background

1.1.1 Introduction to Environmental Degradation and Carbon Dioxide Emissions

Environmental degradation is getting more and more serious currently. It inspires us to study the cause of the environmental degradation. Environmental degradation is proxied by CO_2 emissions since CO_2 is the main GHG that lead to environmental degradation. Udara Willhelm Abeydeera, Wadu Mesthrige and Samarasinghalage (2019) highlighted that CO_2 is defined as a gas which has no colour, no odour and non-poisonous formed through burning of carbon and through respiration of living things. In 1990, CO_2 emissions are recorded at 22.15 Gt, and it had increased dramatically to 36.14 Gt in 2014. The global temperature will increase as well as the CO_2 emissions increase. Since the Industrial Revolution, the atmospheric concentration of CO_2 has been increasing rapidly due to human activities and it has now reached threatening level. Human activities such as burning of oil, coal and gas for vehicular transportation and power generation as well as deforestation was the primary cause of CO_2 concentration increased in the atmosphere on the Earth ("CO2 Human Emissions," 2017). Climate change happen due to the emissions of GHG, it has caused many issues to the global world such as global warming, ecosystem imbalance, economic issues, technological problems and societal problems.

Other than this, high concentration of CO_2 also will cause greenhouse effect because the gases absorb the heat energy from the sun and trap the heat close to Earth's surface. Thus, the heat energy will cause rising in temperature of the Earth's atmosphere and further contribute to rising in sea level which is considered as global warming. Nunez (2019) also found that it is also affecting the weather and wildlife population and habitats. When extreme weather appears, it would increase the risk of wildfires, crops production reduced and clean water shortage.

Lastly, the use of internet has become necessity for every family as most of the people nowadays owns a smartphone which need access to internet to carry out most function. It is identified that the search for a web address need about 3.4 Wh (0.8g CO_2 equivalent) ("Do I Emit," n.d.).

1.1.2 Overall Trend of Carbon Dioxide Emissions

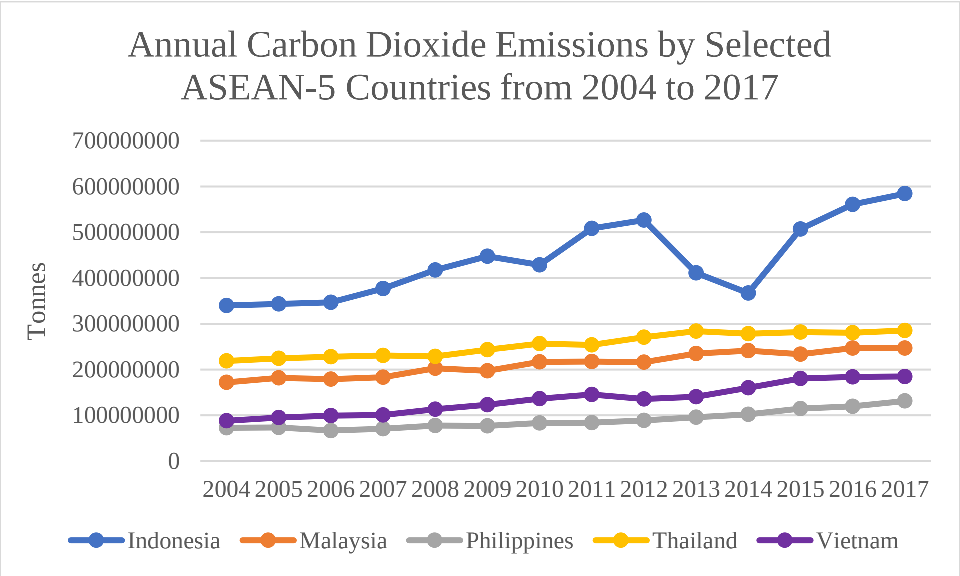

Figure 1.1. Annual Carbon Dioxide Emissions by selected ASEAN-5 Countries from 2004 to 2017. Adapted from Our World in Data. (2019).

The Figure 1.1 illustrate the Annual CO_2 that had been released by Indonesia, Malaysia, Philippines, Thailand and Vietnam from 2004 to 2017. Overall, within the time period, the Annual CO_2 that released by Indonesia recorded a fluctuated trend while the Annual CO_2 that released by Malaysia, Philippiness, Thailand and Vietnam recorded a trend of stable increased. Besides that, the Annual CO_2 that released by Indonesia was maintained at the highest level while the Annual CO_2 that released by Philippines was maintained at the lowest level among the selected countries.

If we look at the trends over time, it is clear that the Annual CO_2 that released by Indonesia had went up from 2004 to 2012, but it showed a dramatic decreased in 2013 and 2014 and went up again afterward. Nasih, Harymawan, Paramitasari and Handayani (2019) found that the main reason that affected the dramatic decreased of the annual emmisions of CO_2 by Indonesia in 2013 was due to the encouragement from the government to companies to produce their products at the lowest emissions of CO_2 and putting effort to implement CO_2 emmisions management practices. In addition, during the time period from 2004 to 2017, the Annual CO_2 that released by Malaysia, Philippines, Thailand and Vietnam had grew consistently.

1.1.3 Current Issues

Stewart (2019) mentioned that Amazon has highest biodiversity in the world because it has approximately 30% of the world’s known species and around 390 billion of tress living in the Amazon forest. Due to this, Amazon had been recognized as the world largest tropical rainforest. Moreover, there are around 20% of the world’s oxygen turnover produces by the Amazon forest area. Therefore, Amazon is a significant character in reducing the level of CO_2 that had been released to the atmosphere and significant in fighting against climate change. Sullivan (2019) found that the Amazon was burned for the development of economy because agriculture is the main sector that contribute to the economy in Brazil. By destroy the Amazon forest area, Brazil can have more places for agriculture development and thus enhance their country's economy.

Nangoy (2019) highlighted that Indonesia was recognized as the fifth-largest contributor of GHG because Indonesia burn their forest frequently for agriculture purpose in which Indonesia had burned around 857,756 hectares and 529,267 hectares of the forest area in 2019 and 2018 respectively. Jong (2019) mentioned that the CO_2 that released by Indonesia in 2019 is the double emissions from the fires in Amazon in which Indonesia had released approximately 708 million tons of GHG in 2019.

Besides that, toxic gases had been released from the deforestation activities at Indonesia in 2019 and thus it had caused the serious impacts such as possessing the worst haze level among the year and affect the health conditions of the resident in Southeast Asia such as Singapore, Thailand, Malaysia and others. Last but not least, the habitat of orangutans and tigers had been destroyed from these deforestation activities. ("Indonesian Fires Burnt," 2019).

Camla (2020) mentioned that there are around 3000 homes, 25,000 koalas, 30 percent of the koalas' habitat, and 33 peoples were sacrificed and destroyed from the bushfire in Australia. The climate change and months of severe caused Australia experienced the hottest and driest weather in 2019 in which the temperature had reached 41.9 degrees Celsius on 18 December 2019. This worsened and spread the bushfires in Australia and caused approximately 25.5 million acres of the area to be burned.

1.2 Research Problem

CO_2 emissions are the cause of environmental degradation and it is always a serious issue that being concerned at all time. Burning of fossil fuels and other human-induced behaviors are reasons that contributed to increase in CO_2 emissions. Therefore, we aim to examining the effects of GDP, FDI Inflows, DCTPS, and individuals using the internet on CO_2 emissions in Indonesia, Malaysia, Philippines, Thailand and Vietnam.

GDP is used to proxy the economic growth. According to WDI and Our World in Data, GDP and CO_2 emissions in Indonesia, Malaysia, Thailand, Philippines and Vietnam shown a same upward trend from 2004 to 2017. However, among the selected ASEAN-5 Countries, the GDP and CO_2 emissions of Indonesia recorded at the highest level. Cox and Cox (2020) found that the input of energy is important in stimulating a country's economy. Therefore, the growth of economy of one country will caused an increase in the CO_2 emissions. As a result, GDP and CO_2 emissions will record the same moving pattern. For example, the GDP of U.S. had increased from $18.2 trillion in 2015 to $19.5 trillion in 2017, at the same time CO_2 emissions in U.S. had increased from 400 ppm in 2015 to 405 ppm in 2017. Moreover, the coronavirus pandemic has caused many countries to restrict and lockdown their country. This had reduced economic activity and thus result in a reduction in the CO_2 emissions. As an evidence, China which consider as the country that record high economy activities had successfully reduced their CO_2 emissions by 25% due to the coronavirus lockdown (World Meteorological Organization, 2020).

Other than that, FDI Inflows of the chosen countries are fluctuated from 2004 to 2017. FDI Inflows is expected to affecting the CO_2 emissions because FDI Inflows will boost the economic growth, new business will be set up and there will also be an expansion of existing business. This will encourage more business activities such as production, export and import. However, the combustion of fossil fuel from the production factory will result in emissions of GHG such as CO_2, especially power plant and also industry that using own electricity and heat production. In 2017, industry contributed over half of the CO_2 emissions (European Environment Agency, 2020). But, FDI Inflows might also bring a positive impact toward the environment as more modern and environmental-friendly technology is transfer from one country to another through connection of FDI (OECD, 2002).

Furthermore, financial development which can proxied by DCTPS is affecting the economic growth of countries in Asia. Among the countries that we choose to study, Malaysia, Thailand, Philippines and Vietnam had grown about 20% in their debt ratio from 2010 to 2017 while Indonesia does not have significant increase in their debt ratio. Thus, this indicate that the private sectors in the countries above have increased their financial leverage to finance their businesses or expand their businesses. As the business have more fund available, the business will most likely increase their production line or invest in project like having more manufacturing plant (OECD, 2018). On the other hand, the households in Thailand and Malaysia also have higher demand for more credit as they want to invest in real estate and consumer goods. When the spending level among households increases, it is believed that it would contribute to economy growth because businesses were earning more profit and therefore produce more CO_2 (OECD, 2018).

Lastly, by living in the 21st century, technological advancement has made the life of every individual more convenient and improved their lifestyle. However, technology advancement could negatively affect the environment. The GHG emissions have increased by approximately 8% because of the digital technology. In addition, the CO_2 emissions contributed by OECD countries in digital technology have shown an upward trend over time. According to the report, it increased about 450 million tons starting from 2013 (The Shift Project, 2019). In order to verify the fact, we used the percentage of the individuals from the population that using the internet as a proxy of internet use to test its impact on the CO_2 emissions in selection countries in this study. According to the data of WDI, individuals using the internet in selected ASEAN-5 countries are increased gradually from 2004 to 2017. Furthermore, 2017 was the year that recorded as the highest number of individuals using the internet for all five countries among the sample period (World Bank, 2020). We predicted that the number of individuals that using the internet will getting higher continuously as technology is getting more advanced in this 21st century. Therefore, the impact of internet use on the CO_2 emissions is worthy of public attention.

1.3 Research Questions

i. Is relationship being captured between CO_2 emissions and GDP?
ii. Is relationship being captured between CO_2 emissions and FDI Inflows?
iii. Is relationship being captured between CO_2 emissions and DCTPS?
iv. Is relationship being captured between CO_2 emissions and individuals using the internet?

1.4 Research Objectives

i. To study the relationship of CO_2 emissions and GDP.
ii. To study the relationship of CO_2 emissions and FDI Inflows.
iii. To study the relationship of CO_2 emissions and DCTPS.
iv. To study the relationship of CO_2 emissions and individuals using the internet.

1.5 Research Significance

Environmental degradation is serious issues or risks which the world is exposed currently. The rich natural resources in ASEAN countries is important to support the economic activities and promote the growth of a nation. However, it is a biggest challenge for ASEAN countries to achieve a balance between environmental sustainability and growth of economy. Thus, study the causes of environmental degradation (CO_2 emissions) and find an effective way to address this problem is necessary.

The relationship between CO_2 emissions and the combination of four independent variables examined in this research. Although the effects of GDP, FDI Inflows and DCTPS towards the CO_2 emissions are well studied by several researchers, but deficiencies are found between the result of the researches as the methodologies employed, the scope and sample period that had chosen are different. Therefore, the result obtained from these researches cannot be fully references by ASEAN countries. So, one of the contributions of this study are capture the effect of these variables in ASEAN countries.

In addition, the use of internet is become more frequent since we are start moving toward the Industry 4.0. Intensive usage of internet may negatively impact the environment. However, there is an argument that internet increase efficiency and will further mitigate the CO_2 emissions. The relationship between two variables need further investigation as it has not yet been studied comprehensively. So, we seek to bring up society attention and included individuals using the internet in our model to fulfill the gap in existing research.

This study will provide a useful and clearer information of environmental degradation and its determinants. This helps the government to impose an appropriate strategy to take care of and improve the standard of the environment. Therefore, this research may also serve as the reference for the government policymakers while implement new policy or making an adjustment on the existing laws and policies.

Last but not least, the result of our research enables the reader to have more details and a deeper understanding of the current situation or condition of our environment. It can further enhance the reader's attention, awareness and enthusiasm in finding out a solution to address the current environmental issue. This research also providing information as a reference which beneficial to other researchers that wish to conduct research in this area.

1.6 Organization of Study

The first chapter gives an overview of the environmental degradation, the problems arises, objectives, significance and organization of the study. The second chapter covers the theoretical and empirical review of the existing research, framework and hypotheses of research for this study. The third chapter includes the model design, data collection procedure and the proposed methodologies on model estimation, model selection and diagnostics checking. The fourth chapter will discuss the result of the proposed methodologies. The fifth chapter covers the summarization result and limitation of this study. It also includes the recommendations for future research in related field.

1.7 Conclusion

The environment is degraded time over time and affected by the human activities such as deforestation in Amazon and Indonesia. The objectives of this research are to study the relationship exists between environmental degradation (proxied by CO_2 emissions) and GDP, FDI Inflows, DCTPS and individuals using the internet in selected ASEAN-5 countries (Indonesia, Malaysia, Thailand, Philippines and Vietnam).

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

Hypotheses development, theories and review from the past studies regarding factors contributed to CO_2 emissions are included in this chapter.

2.1 Underlying Theories

2.1.1 Environmental Kuznets Curve Hypothesis

Dinda (2004) found that by referring to the idea of KC, the concept of EKC had been further extend in 1990s and onward. EKC Hypothesis propose that inverted U-shape relationship is captured among the growth in economy and environmental degradation.

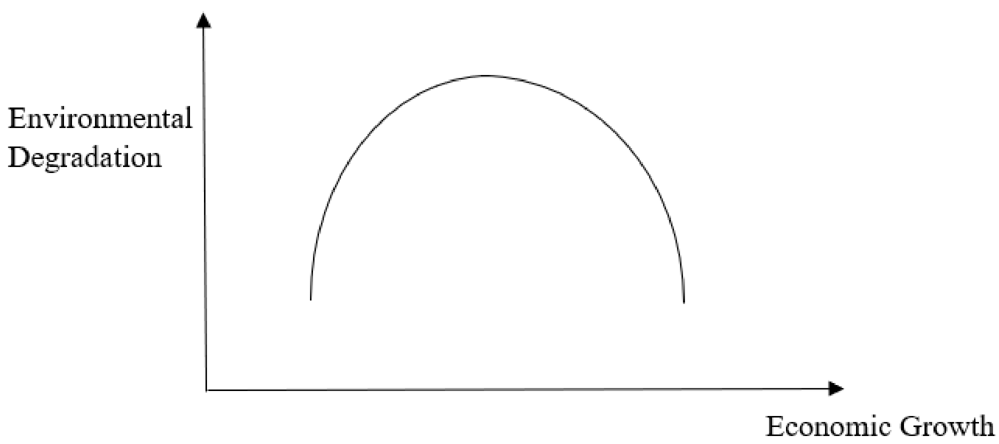

Figure 2.1. Environmental Kuznets Curve. Adapted from Dinda, S. (2004). Dinda, S. (2004). Environmental Kuznets curve hypothesis: a survey. *Ecological economics*, *49*(4), 431-455.

Based on Figure 2.1, EKC Hypothesis expected that in order to promote economic growth people will use more resources to produce more energy as to hasten the development without concern about the situation of the environment. As a result, the environment will start to degrade due to pollution cause by human activities like deforestation, throw industrial waste into the sea, burning of coal, burning of fossil fuel and reached the peak. When the country has reached high level of development, they will notice the importance of clean environment and start to cope with the pollution by spending income to reduce or slow down the pollution.

EKC Hypothesis also considered technology advancement as one of the factors that stimulate a growth in the economy and at the same time help to reduce the pollution to environment. Some cars in recent year were developed to be powered by electricity which shows the improvement in technologies lead to the decrease of fossil fuel as it was slowly replaced by renewable energy and thus decreasing the CO_2 emissions. Gonel and Akinci (2018) found that it can also be related to the use of internet as it contributed to technological advancement in which changes the form of production and communication that lead to environment sustainability. The use of internet by government also helps in the improving the effectiveness of policy, efficiency of governing, and democratic responsiveness leads to cultivate of ecological awareness and sustainability.

Zhang and Meng (2019) mentioned that penetration of the internet in the starting point to the economic threshold is positive correlated in low-income countries but negative correlated in more developed countries. In other words, penetration of internet in low-income countries will help them to stimulate a growth in their country's economy. However, for country with high level income, penetration of internet will help them to improve their environment quality.

The relationship between financial development and environment also can be explained through EKC Hypothesis. Haseeb, Xia, Danish, Baloch, and Abbas

(2018) found that an efficient financial system will promotes economic activities in a country. The improvement of financial network helps in decrease the financing cost, increasing the purchase of industrial equipment and machinery. The increase of purchasing lead to increase in production, and causes the increase of energy usage and CO_2 emissions. According to Haseeb et al. (2018), the mitigation of the CO_2 emissions happens after the threshold level which validates the EKC Hypothesis.

2.1.2 Pollution Haven Hypothesis

Rasit and Aralas (2017) proposed that the hypothesis of Pollution Haven suggests that industry or firms to change location to countries with weaker environmental policy. Based on the concept of this hypothesis, when FDI increase will caused an increase in the pollution level in developing countries because government will try to loosen their environmental policy to attract foreign investor. As a result, firms and businesses can avoid cost of strict regulation such as penalty or fine when the firm produce pollution and waste above the acceptable level. As globalization is common in this generation, it encourages the polluting industries to other countries which have loose environmental policy. It also encourages the dumping of nuclear and other hazardous waste from developed countries to developing countries.

Maku, Adegboyega, and Oyelade (2018) found that extraction of non-renewable resources such as petroleum, fossil fuel in developing countries from companies hugely affect the environmental policy and causes huge impact to the environment, production, and trading among countries. As countries that implemented strict regulation have higher cost to bear compare to countries that have loose regulation, it will affect investment decision and thus affect the FDI from polluting industries towards developing countries. FDI will cultivate environmental issue in the developing countries as more companies were attracted to invest in developing countries. Studies on high-income group for 1970-2012 stated the negative relationship between FDI and

CO_2 emissions. Kizilkaya (2017) found that studies on high pollution industry also shows that the uni-directional causality of CO_2 emissions and FDI which validate the Pollution Haven Hypothesis.

2.2 Review of Variables

2.2.1 Gross Domestic Product and CO_2 Emissions

GDP can be used to determine the growth of a nation's economy. Al-Mulali, Tang, and Ozturk (2015) mentioned that FMOLS is conducted based on the sample data in Latin America and Caribbean countries within the time period 1980 to 2010. The test is to investigate is there any relationship between GDP and CO_2 emissions, and the result shown that it is consistent with the EKC Hypothesis (inverted-U shape).

According to Al-Mulali et al. (2015), energy efficiency and used of renewable energy might be the reason that caused inverted-U shape relationship being captured in the investigated countries. Moreover, similar result is found in Turkey by Ozturk and Acaravci (2013) and Kaya, Kayalica, Kumas, and Ulengin (2017) in 1960 to 2007 and 1974 to 2010 respectively. It is also consistent with analysis of Arouri, Youssef, M'henni and Rault (2012) at regional-level that based on the sample data in Middle East and North African countries within the time period 1981 to 2005.

Kizilkaya (2017) mentioned that ARDL bound testing approach had been conducted based on the sample data in Turkey within time period 1970 to 2014, positive relationship is captured between GDP and CO_2 emissions. According to Kizilkaya (2017), fossil fuels is needed to meet the energy demand of a country in order to sustain the economy growth, this is also the main reason that caused the resulted relationship. Besides, a similar result is found by Islam, Abdul Ghani, and Mahyudin (2017) in Malaysia, Indonesia, Thailand from 1991 to 2010 and Farhani and Ozturk (2015) in Tunisia from 1971 to 2012. Ali et al. (2019) also found that a positive relationship exists between for two variables in Nigeria for long run from 1971 to 2010.

Park, Meng and Baloch (2018) found that there is a negative relationship between GDP and CO_2 emissions in analysis in European Union from 2001 to 2014. According to Park (2018), economic growth can deduct the CO_2 emissions. Tsaurai (2019) found that positive relationship is captured between GDP and CO_2 emissions from the test that employed POLS model which based on the sample data in West Africa countries within time period 2003 to 2014. However, by using the same sample data, an insignificant relationship is captured under the test that employed FEM and REM.

Omri, Nguyen, and Rault (2014) had conducted a panel data analysis that across 54 countries from 1990 to 2011 using Arellano and Bond (1991) GMM estimator. According to Omri et al. (2014), a result of insignificant relationship is captured in global analysis, Europe and North Asia analysis, Latin America and Caribbean analysis. While a positive relationship is recorded in Middle East, North Africa, and sub-Sahara analysis. A unidirectional causal link is found between two variables.

2.2.2 Foreign Direct Investment Inflows and CO_2 Emissions

Omri, Nguyen, and Rault (2014) found that Arellano and Bond (1991) GMM estimator had been conducted based on the sample data in 54 countries within time period 1990 to 2011 that collected from WDI. Global panel analysis, Middle East, North Africa, sub-Sahara analysis and Latin America and Caribbean analysis generated a result of positive relationship between FDI Inflows with CO_2 emissions. While an insignificant relationship is found between two variables in Europe and North Asia analysis. According to Omri et al. (2014), lowering of environmental regulation could retain and attract foreign investor.

Kılıçarslan and Dumrul (2017) found that the FDI Inflows is positively correlated with CO_2 emissions in the long run. This research employed Johansen Cointegration test and VECM based on the sample data in Turkey within time period 1974 to 2013 that collected from the WDI. Natural logarithm had applied in order to obtain better regression result and reduce the autocorrelation and heteroscedasticity.

Kaya, Kayalica, Kumaş, and Ulengin (2017) mentioned that the relationship between FDI Inflows and CO_2 emissions recorded a negative result in the short run and positive result in the long run. This research employed cointegration test and ADF test based on the sample data in Turkey within time period 1974 to 2010 that collected from the WDI and Central Bank of the Republic of Turkey. Natural logarithm is used in order to reduce heteroscedasticity problem.

Tsaurai (2019) mentioned that this research collected a sample data for 12 West Africa countries within time period 2003 to 2014 from African Development Bank, IMF and WDI. Under this research, natural log is used to reduce heteroscedasticity and POLS, FEM and REM is employed based on the sample data. Through the regression result, it showed us that FDI Inflows is significant and negatively related with CO_2 emissions in POLS but insignificantly with the CO_2 emissions in the test of FEM and REM.

2.2.3 Domestic Credit to Private Sector and CO_2 Emissions

Farhani and Ozturk (2015) mentioned that ARDL bounds testing approach to cointegration and ECM was employed based on the sample data in Tunisia within time period 1971 to 2012 that collected from WDI. The result indicated that a positive relationship is recorded between DCTPS has a positive relationship and CO_2 emissions.

Ali et al. (2019) had carried out an ARDL bounds testing approach in Nigeria over the period of 1971 to 2010 based on the data procured from WDI. Based on the result, there is existence of significant positive relationship between DCTPS and CO_2 emissions.

Park, Meng, and Baloch (2018) found that PMG, FMOLS and DOLS was employed based on the sample data in 23 European Union within time period 2001 to 2014 that collected from WDI. The result indicated that a negative relationship is captured between DCTPS and CO_2 emissions.

Al-Mulali, Tang, and Ozturk (2015) found that FMOLS was employed based on the sample data in Latin America and Caribbean countries within time period 1980 to 2010 that collected from WDI. The result indicated that a negative relationship is recorded between CO_2 emissions and DCTPS.

Ozturk and Acaravci (2013) also carried out ARDL bounds testing approach based on the sample data in Turkey within time period 1960 to 2007 that obtained from WDI. All the data had been transformed to natural logarithm. The result indicated that an insignificant relationship is recorded in long run

Tsaurai (2019) mentioned that POLS, FEM and REM was employed based on the sample data of 12 West Africa countries within the time period 2003 to 2014 that collected from WDI, IMF, and African Development Bank. This research had used three different indicators to proxy financial development which is domestic credit provided by financial sector, DCTPS by banks and broad money. An insignificant relationship is capture for all proxies under the FEM and REM estimation. As for POLS estimation, a positive relationship is captured for model using domestic credit provided by financial sector as proxy while insignificant relationship is captured for model using DCTPS by banks and broad money as proxy.

2.2.4 Individuals using the Internet and CO_2 Emissions

Park, Meng, and Baloch (2018) mentioned that PMG, FMOLS, and DOLS was employed based on the sample data on 23 European Union countries within the time period from 2001 to 2014. Park et at. (2018) had indicated that a positive relationship is captured between individuals using the internet and CO_2 emissions. According to Park et al. (2018), a country could use efficient internet technologies to reduce the CO_2 emissions.

Other than that, Tsaurai (2019) also used this variable as a proxy for the infrastructure development. Based on the result of FEM and REM, the individuals using the internet is found to be insignificantly related to CO_2 emissions in West Africa countries from 2003 to 2014. However, it is positive and significantly related to CO_2 emissions for two out of three model that using different proxy for financial development under POLS estimations.

2.3 Proposed Framework

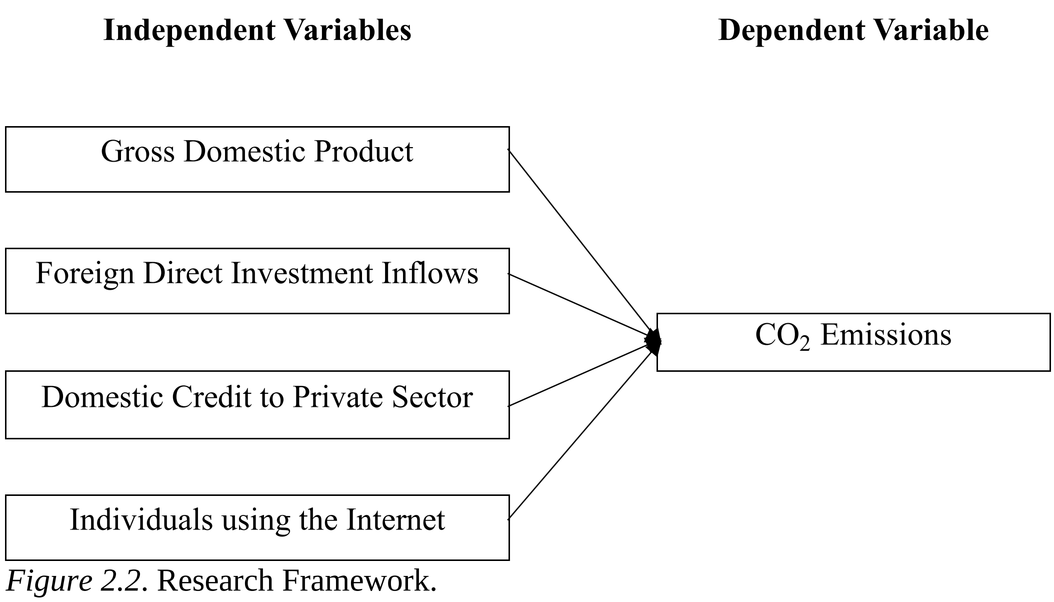

Figure 2.2. Research Framework.

2.4 Hypotheses Development

2.4.1 Gross Domestic Product and CO_2 Emissions

H_0: Insignificant relationship is captured between GDP and CO_2 emissions.
H_1: Significant relationship is captured between GDP and CO_2 emissions.

2.4.2 Foreign Direct Investment Inflows and CO_2 Emissions

H_0: Insignificant relationship is recorded between FDI Inflows and CO_2 emissions.
H_1: Significant relationship is recorded between FDI Inflows and CO_2 emissions.

2.4.3 Domestic Credit to Private Sector and CO_2 Emissions

H_0 : Insignificant relationship is captured between DCTPS and CO_2 emissions.
H_1 : Significant relationship is captured between DCTPS and CO_2 emissions.

2.4.4 Individuals using the Internet and CO_2 Emissions

H_0: Insignificant relationship is recorded between individuals using the internet and CO_2 emissions.

H_1 : Significant relationship is recorded between individuals using the internet and CO_2 emissions.

2.5 Conclusion

This chapter is mainly to discuss whether GDP, FDI Inflows, DCTPS and individuals using the internet has any effect on CO_2 emissions. Besides, EKC Hypothesis, and Pollution Haven Hypothesis also been discussed in this research. We had reviewed the information regarding the sampling model and result of past studies and obtained a conclusion that the scope of study and methodology employed would generate different result for the relationship between CO_2 emissions and the chosen independent variables in this study.

CHAPTER 3: METHODOLOGY

3.0 Introduction

This chapter covers the information that related to the variables used such as definition, sources and data collection procedure. Other than that, this chapter also covers the research model design and the methodologies that applied to test on the model.

3.1 Research Design

This research investigating how the combination of four explanatory variables including GDP, FDI Inflows, DCTPS and individuals using the internet are affects CO_2 emissions.

3.1.1 Basic Model

The basic model is adopted from Kılıçarslan and Dumrul (2017). The functional form of the basic model will be stated as:
CO_2= f (FDI)

The econometric model of the basic model is:

$$ln\ (CO_2)_{\ it} = \beta_0\ + \beta_1 ln(FDI)_{it} + \varepsilon_{it}$$

Where,

$ln(CO_2)_{it}$ = Natural logarithm of Carbon Dioxide Emissions (kt)

$ln(FDI)_{it}$ = Natural logarithm of Foreign Direct Investment, net inflows (BoP, current US$)

β = Parameter i=0,1

ε = Error Term

t = 1974, 1975, 1976 2013

i = Turkey

3.1.2 Empirical Model

After taken into account the impact of GDP, FDI Inflows, DCTPS, and individuals using the internet we extend the model adopted by Kılıçarslan and Dumrul (2017). The functional form of the extension model will be stated as:

CO_2= f (GDP, FDI, DCTPS, ICT)

The econometric model will be stated as:

$$\ln(CO_2)_{it} = \beta_0 + \beta_1 ln\,(GDP)_{it} + \beta_2 ln\,(FDI)_{it} + \beta_3 ln\,(DCTPS)_{it} + \beta_4\, ICT_{it} + \mu_{it}$$

Where,

$ln\,(CO_2)_{it}$	=	Natural logarithm of Cardon Dioxide Emissions (tonnes)
$ln\,(GDP)_{it}$	=	Natural logarithm of Gross Domestic Product (current US$)
$ln\,(FDI)_{it}$	=	Natural logarithm of Foreign Direct Investment, net inflows (BoP, current US$)
$ln\,(DCTPS)_{it}$	=	Natural logarithm of Domestic Credit to Private Sector (% of GDP)
ICT_{it}	=	Individuals using the Internet (% of population)
β	=	Parameter, i=0,1,2,3,4
μ	=	Error Term
t	=	2004, 2005, 2006 …... 2017
i	=	Indonesia, Malaysia, Philippines, Thailand and Vietnam

3.2 Sampling Design

We carried out panel data analysis that involved Indonesia, Malaysia, Philippines, Thailand and Vietnam from the year 2004 until 2017. Our World in Data and WDI are where we obtained the data sources. Owing to the shortage of data of individuals using the internet in the Philippines, thus the final sample period is decided from the year 2004 to 2017.

3.3 Data Collection Methods

In this research project, we applied secondary data and it is downloaded from WDI and Our World in Data.

Table 3.1

Definition and sources of variables

Variable	Definition	Source
Carbon Dioxide Emissions (annual, tonnes)	Carbon dioxide emissions refers to the direct release of carbon dioxide gas from the combustion of fossil fuel as well as those from the cement production.	Our World in Data
Gross Domestic Product (current US$)	Gross domestic product is the total gross value from all the producers which were resident in the economy as well as adding taxes and deducting subsidies from the product. Fabricated asset was not deducted on the depreciation along with value factors of natural resources like depletion and degradation.	WDI
Foreign Direct Investment, net	Foreign direct investment is the flow of equity from the direct investment by foreigners to an economy. It involved	WDI

inflows (BoP, current US$)	reinvestment of earning, total equity capital and other capital. Direct investment involved investment of a resident in one economy in other countries while also having significant or some degree of authority on the company or enterprise's management which is a resident in another economy. To be valid for a direct investment, the ownership for ordinary share or the voting power must be at least 10 percent or above.	
Domestic Credit to Private Sector (% of GDP)	Domestic credit to private sector can be defined as the funding resources from financial sector to private sector range from non-equity financial securities such as bond and option, loans and other trade credits.	WDI
Individuals using the Internet (% of population)	Individual involved in using the internet for the past three months no matter the location is known as internet user. The usage of internet can be from devices ranging from cell phone, laptop, television etc.	WDI

After downloading, we combined all single data into one Microsoft Excel file in order to run the result using EViews. Furthermore, we also log the data for four variables which are CO_2 emissions, GDP, FDI Inflows and DCTPS in EViews in order to smoothing the estimation.

3.4 Model Estimation

3.4.1 Pooled Ordinary Least Squares

Owing to the panel data is employed in this research, thus we adopted POLS for the analysis. There are three assumptions apply on the POLS Model which the objects of study must have the same intercept, same slope and time invariant. There are two conditions that must be fulfilled when measure POLS Model. The first condition is the objects of study must be homogeneity across periods. Homogeneity means that the observation carries the same characteristic over period of time. The second condition is the error terms (ε_i) and the independent variables (X_{it}) are uncorrelated as to prevent bias. Hiestand (2005) mentioned that he used POLS Model as purposes of comparison by compare it to the FEM since their cross-sectional data is small. The example of equation of POLS model is as below.

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

The drawback of this model is it could not capture the changes in characteristic or effects that occur in the observations across periods. Another drawback is the model is unable to measure observation that is heterogeneity or else the result produced will be biased, inefficient and inconsistent.

3.4.2 Fixed Effects Model

Brüderl and Ludwig (2015) found that FEM investigate every observation based on an intercept term without including time effect. Therefore, with FEM, users are allowed to have an unbiased estimation in panel data. Under FEM, there are few possibilities, assumptions or conditions. Firstly, we assume that each observation has different intercept but with same slope and has no time effect.

$$Y_{it} = \alpha_0 + \alpha_1 D_S + \alpha_2 D_H + \beta_1 X_{1\,it} + \mu_{1\,it}$$

The second condition is each observation has different intercept and slope but with no time effect. Under this condition, we will still include the cross-sectional dummies and form a model as shown below.

$$Y_{it} = \alpha_0 + \alpha_1 D_s + \alpha_2 D_H + \beta_1 X_{1\,it} + \gamma_1 D_S X_{1\,it} + \gamma_2 D_H X_{1\,it} + \mu_{1\,it}$$

The third condition is each observation has different intercept, and has time effect but the slope is constant. Under this condition, we will include cross-sectional dummies and time dummies in our model.

$$Y_{it} = \alpha_0 + \alpha_1 D_s + \alpha_2 D_H + \lambda_0 + \lambda_1 D_1 + \lambda_2 D_2 + \lambda_3 D_3 + \beta_1 X_{1\,it} + \mu_{1\,it}$$

Moreover, Hanck, Arnold, Gerber and Schmelzer (2020) highlighted that the fourth condition of estimating FEM is the model include α_i which it captures the individual specific error and it is not constant. Then, demean is applied on the dependent variable or independent variables in the group in order to measure the model. Therefore, we can use OLS to estimate the model after the transformation and at the same time capture the individual specific error.

$$Y_{it} = \beta_1 + \beta_2 X_{1it} + \cdots + \alpha_i + \mu_{it}$$
$$\bar{Y} = \beta_2 \bar{X}_{1i} + \cdots + \bar{\alpha_i} + \bar{\mu_i}$$
$$(Y_{it} - \bar{Y}) = \beta_2 (X_{1it} - \bar{X}_{1i}) + \cdots + (\alpha_i - \bar{\alpha_i}) + (\mu_{it} - \bar{\mu_i})$$

3.4.3 Random Effects Model

REM is used to analyse the panel data, where the cross-section or individual-specific effect is assumed to be random or not constant and is not correlated with independent variables. Nwakuya and Ijomah (2017) mentioned that one of the advantages of REM is it can include time invariant variable like gender. The aims of REM are to investigate the individual's characteristics which contain in the sample based on random error terms. Thus, there were few assumptions applied on the REM which the error term (ε_i) is assumed that it is not correlated with the independent variables. Another assumption is that we assume that observations in the sample has no time effect which is time invariant. Williams (2012) found that REM could be measured using GLS. The example equation of REM is shown below.

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

Next, Dieleman and Templin (2014) state that the estimation of REM rely on assumption of OLS. When estimating REM, the model must fulfil the conditions that the model is correctly specified, independent variable (X_{it}) is exogenous and linearly independent, then residual need to be independently and identically distributed. Independent variable is exogenous mean that the independent variable is not affect by other variable that consist in the system. There is extra assumption for REM which is the explanatory variable need to be independent as to avoid omitted variable. After all assumptions are fulfilled, the estimation of REM can be considered to be unbiased and efficient.

3.5 Model Selection

3.5.1 Likelihood Ratio Test

We will employ Likelihood Ratio Test to evaluate whether the POLS or FEM is more desirable and fits the model better.

H_0: POLS is more favourable.

H_1: FEM is more favourable.

Decision Rule: H_0 is rejected when p-value is less than α. Otherwise, H_0 will not be rejected.

3.5.2 Breusch-Pagan Lagrange Multiplier Test

We will apply Breusch-Pagan Lagrange Multiplier Test to test either the POLS or REM is more desirable and fits the model better.

H_0: POLS is more favourable.

H_1: REM is more favourable.

Decision Rule: H_0 is rejected when p-value is less than α. Otherwise, H_0 will not be rejected.

3.5.3 Hausman Test

Moreover, Hausman Test also will be used to test whether the FEM or REM is more desirable and fits the model better.

H_0: REM is more favourable.

H_1: FEM is more favourable.

Decision Rule: H_0 is rejected when p-value is less than α. Otherwise, H_0 will not be rejected.

3.6 Diagnostics Checking

3.6.1 Unit Root Test

Glen (2016) found that unit root test is applied to determine whether the variables in the model are stationary and no unit root. Non-stationary means that there is a unit root problem. To prevent any regression problem and biased estimation which can lead to inaccurate result, testing the stationarity is an important procedure. It can also be used to test the cointegrated relationship between the variables. Model that consists two or more non-stationary variables will generate high value of R square and t-statistics even when there is no correlation between the variables. To test whether the model suffer from unit root problems, cointegration test can be used on series or variables with first difference which is integration order of I(1). In our research, the test that we used is LLC unit root test. Chapsa, Tabakis and Athanasenas (2018) found that LLC test consider the coefficient of lagged dependent variable's homogeneity across all the panel units.

$\Delta y_{i,t} = a_i + \rho y_{i,t-1} + \sum \theta_{i,j} \Delta y_{i,t-1} + \varepsilon_{i,t}$
where i = 1,2,3,4… and N,t = 1,2,3,4...T.

H_0: The data is non-stationary.
H_1: The data is stationary.

An assumption where an independent and identically distributed is applied for error term across individuals throughout the sample. LLC test can be useful when use on individual cross section which are similar to the autoregressive roots but also found to be at a disadvantage when there is a presence of cross-sectional correlation.

3.6.2 Multicollinearity

Multicollinearity exists when a relationship is captured between the independent variables in the model. However, Gujarati and Porter (2009) found that multicollinearity may not always be an obstacle for researcher to continue on their research because the result that they obtain is still applicable if they do not involve in serious multicollinearity. According to Gujarati and Porter (2009), there are some indicators that can used to identify serious multicollinearity. Firstly, we can use Degree of VIF to identify serious multicollinearity. A conclusion of serious multicollinearity will be obtained if VIF recorded a value of greater than 10. Additionally, TOL considers as one of the indicators in identifying serious multicollinearity. The equation shown below is the formula of TOL.

$$TOL= 1-R^2_{X_1X_2}$$

When a researcher facing serious multicollinearity, it is high possibility that he or she obtain a value that greater than 0.90 for R^2. Therefore, R^2 that greater than 0.90 will lead to a value of TOL that close to 0. As a result, if we obtain the value that lower than 0.1 for TOL, we can conclude that there is a serious multicollinearity.

Last but not least, pair-wise correlation is effective in measuring serious multicollinearity because it is a standard that able the users to know whether is there any relationship between the independent variables. If the pair-wise correlation captured a value that greater than 0.80, it indicates that there is a serious multicollinearity.

3.7 Conclusion

POLS, FEM and REM will be applied for model estimation while Likelihood Ratio test, Breusch-Pagan Lagrange Multiplier Test and Hausman Test will be applied for model selection. Moreover, the LLC unit root test is used to test on the stationary of the variables while pair-wise correlation analysis, VIF and TOL will be used to detect the multicollinearity problem in the model.

CHAPTER 4: DATA ANALYSIS

4.0 Introduction

The generated result from EViews for proposed methodologies that discussed in Chapter 3 had covered in this chapter.

4.1 Descriptive Analysis

Table 4.1

Descriptive Analysis

	LNCO2	LNGDP	LNFDI	LNDCTPS	ICT
Mean	19.07566	26.27466	22.54817	4.200290	31.80274
Median	19.19160	26.32967	22.83013	4.546796	27.74500
Maximum	20.18554	27.64652	23.94696	5.006449	80.14048
Minimum	18.01304	24.53939	18.55752	3.202992	2.600286
Standard Deviation	0.581476	0.683427	0.929697	0.624668	20.85874

Based on the Table 4.1, the summary of variables data was obtained for the selected ASEAN-5 countries which is from year 2004 to 2017. The Table 4.1 shows that the ICT has the highest mean of 31.80274 while LNDCTPS has the lowest mean of 4.200290. The mean value means that the ICT has the highest average value across the set period. The ICT has the highest median which is 27.74500 while LNDCTPS has the lowest median which is 4.546796. The median value is defined as the total value in middle period. In addition, the standard deviation of ICT was the highest with the value of 20.85874 as compare to other variables. Then, the LNCO2 has the lowest standard deviation which is 0.581476. The standard deviation of ICT was the highest due to the difference of maximum value of ICT and mean value of ICT is the largest.

4.2 Unit Root Test

Table 4.2

Unit Root Test

	Level	
	Individual intercept	**Individual intercept and trend**
LNCO2	-0.46977 (0.3193)	-4.84311 *** (0.0000)
LNGDP	-6.48179 *** (0.0000)	-1.41100 * (0.0791)
LNFDI	-3.84777 *** (0.0001)	-4.57772 *** (0.0000)
LNDCTPS	-8.53832 *** (0.0000)	-21.6662 *** (0.0000)
ICT	4.18746 (1.0000)	-7.91027 *** (0.0000)

Note: The asterisk denotes the series is significant at the respective significance level, * for 10%, ** for 5% and *** for 1%.

Table 4.2 are the summarized result of the unit root test by EViews. According to the Table 4.2, all the variables involved shows a stationary movement when tested in level and include individual intercept and trend in test equation. LNGDP is stationary at significance level of 10% while LNCO2, LNFDI, LNDCTPS, and ICT are stationary at significant level of 1%. The result indicates that there are no long-run relationships. There may be short-run relationship which is not necessary for cointegration estimation which required the variables to show stationary movement at integrated of order one or 1(1). The variables are integrated of order zero or I(0).

4.3 Model Estimation

4.3.1 Pooled Ordinary Least Squares

Table 4.3

Pooled Ordinary Least Squares

Variable	Pooled Ordinary Least Squares			
	Coefficient	Standard Error	T-Statistic	Probability
C	-2.504577	1.540229	-1.626107	0.1088
LNGDP	0.717110	0.066389	10.80159	0.0000 ***
LNFDI	0.064732	0.048049	1.347199	0.1826
LNDCTPS	0.371741	0.080717	4.605499	0.0000 ***
ICT	-0.008886	0.002258	-3.935861	0.0002 ***

Note: The asterisk denotes the series is significant at the respective significance level, * for 10%, ** for 5% and *** for 1%.

Refer to the Table 4.3, LNGDP and LNDCTPS recorded a same p-value of 0.0000. Both variables are positive and statistically significant at all significance levels. The p-value of ICT is recorded at 0.0002. Therefore, it is negative and statistically significant at 1%, 5%, and 10%. While LNFDI is not significant at all significance levels as its p-value is as higher as 0.1826.

4.3.2 Fixed Effects Model

Table 4.4

Fixed Effects Model

Variable	Fixed Effects Model			
	Coefficient	Standard Error	T-Statistic	Probability
C	12.76539	0.991228	12.87836	0.0000 ***
LNGDP	0.196485	0.043878	4.477957	0.0000 ***
LNFDI	0.001781	0.012976	0.137287	0.8913
LNDCTPS	0.235293	0.083969	2.802148	0.0068 ***
ICT	0.003749	0.001292	2.901593	0.0052 ***

Note: The asterisk denotes the series is significant at the respective significance level, * for 10%, ** for 5% and *** for 1%.

Refer to the Table 4.4, LNGDP, LNDCTPS, and ICT are recorded a p-value at 0.0000, 0.0068, and 0.0052 respectively. These three variables are positive and significantly affected the LNCO2 at all significance levels.

Furthermore, the p-values of LNFDI is recorded at 0.8913. Thus, it is obvious that LNFDI is insignificant in affecting LNCO2 at significance level of 1%, 5%, and 10%.

4.3.3 Random Effects Model

Table 4.5

Random Effects Model

Variable	Random Effects Model			
	Coefficient	Standard Error	T-Statistic	Probability
C	-2.504577	0.371525	-6.741342	0.0000 ***
LNGDP	0.717110	0.016014	44.78008	0.0000 ***
LNFDI	0.064732	0.011590	5.585074	0.0000 ***
LNDCTPS	0.371741	0.019470	19.09299	0.0000 ***
ICT	-0.008886	0.000545	-16.31688	0.0000 ***

Note: The asterisk denotes the series is significant at the respective significance level, * for 10%, ** for 5% and *** for 1%.

Refer to the Table 4.5, all variables are found to have significant relationship with LNCO2 as all its p-values are recorded at 0.0000. LNGDP, LNFDI, and LNDCTPS are positively related and statistically significant at all significance levels. As for the ICT, it is negatively related and statistically significant at 1%, 5% and 10%.

4.4 Model Selection

4.4.1 Likelihood Ratio Test

Table 4.6

Likelihood Ratio Test

Test	P-value
Likelihood Ratio Test	0.0000 ***

H_0: POLS is more favourable.

H_1: FEM is more favourable.

Decision Rule: H_0 is rejected when p-value is less than α. Otherwise, H_0 will not be rejected.

Decision Making: H_0 will be rejected due to the lower p-value (0.0000) as compared to α at 1%, 5% and 10%.

Conclusion: FEM is more favourable.

4.4.2 Breusch-Pagan Lagrange Multiplier Test

Table 4.7

Breusch-Pagan Lagrange Multiplier Test

Test	P-value
Breusch-Pagan Lagrange Multiplier Test	0.0000 ***

H_0: POLS is more favourable.

H_1: REM is more favourable.

Decision Rule: H_0 is rejected when p-value is less than α. Otherwise, H_0 will not be rejected.

Decision Making: H_0 will be rejected due to the lower p-value (0.0000) as compared to α at 1%, 5% and 10%.

Conclusion: REM is more favourable.

4.4.3 Hausman Test

Table 4.8

Hausman Test

Test	P-value
Hausman Test	0.0000 ***

H_0: REM is more favourable.

H_1: FEM is more favourable.

Decision Rule: H_0 is rejected when p-value is less than α. Otherwise, H_0 will not be rejected.

Decision Making: H_0 will be rejected due to the lower p-value (0.0000) as compared to α at 1%, 5% and 10%.

Conclusion: FEM is more favourable.

4.5 Multicollinearity

4.5.1 Pairwise-Correlation Analysis

Table 4.9

Pairwise-Correlation Analysis

	LNCO2	LNGDP	LNFDI	LNDCTPS	ICT
LNCO2	1.000000	0.799995	0.547636	0.062085	0.003270
LNGDP	0.799995	1.000000	0.504465	-0.190979	0.058945
LNFDI	0.547636	0.504465	1.000000	0.222189	0.218903
LNDCTPS	0.062085	-0.190979	0.222189	1.000000	0.625237
ICT	0.003270	0.058945	0.218903	0.625237	1.000000

Serious multicollinearity will be capture if the value of pairwise-correlation is greater than 0.80. Refer to the Table 4.9, the pairwise-correlation between independent variables is recorded at the value lower than 0.80. This indicate that the independent variables of our report do not suffer from serious multicollinearity.

4.5.2 Variance Inflation Factor

Table 4.10

Variance Inflation Factor

VIF = 1	No multicollinearity
1 < VIF < 10	No serious multicollinearity
VIF > 10	Serious multicollinearity

Variable	VIF	Result
LNGDP	1.613370	No serious multicollinearity
LNFDI	1.563898	No serious multicollinearity
LNDCTPS	1.992411	No serious multicollinearity
ICT	1.738045	No serious multicollinearity

The VIF result for our variables is recorded at the value that is much lower compared to 10. Therefore, our model is free from serious multicollinearity.

4.5.3 Tolerance

Table 4.11

Tolerance

TOL close to 1	No serious multicollinearity
TOL close to 0	Serious multicollinearity

Variable	R_j^2	TOL ($1-R_j^2$)	Result
LNGDP	0.380179	0.619821	No serious multicollinearity
LNFDI	0.360572	0.639428	No serious multicollinearity
LNDCTPS	0.498095	0.501905	No serious multicollinearity
ICT	0.424641	0.575359	No serious multicollinearity

Based on the Table 4.11, the result of TOL for our variables is far away from 0. This indicate that our model does not involve in any serious multicollinearity issue. In a nutshell, by refer to the result of pair-wise correlation, Degree of VIF, and TOL that we obtained, we can conclude that our research is free from serious multicollinearity issue.

4.6 Conclusion

By referring to the result that we obtained, FEM is the best model that suit to our research. We also found that GDP, DCTPS, and individuals using the internet are significantly affect the CO_2 emissions while the FDI Inflows is not significantly related to the CO_2 emissions in the selected ASEAN-5 countries from 2004 to 2017. The result of LLC unit root test indicates that the variables are stationary at level form. Lastly, according to the result of VIF, TOL, and pair-wise correlation analysis, we obtain a conclusion that the model of this study is free from serious multicollinearity.

CHAPTER 5: DISCUSSION, CONCLUSION, AND IMPLICATIONS

5.0 Introduction

The first part will cover the summary of main findings that been discover in the analysis done in Chapter 4. Implications of the study which is recommendation for different authorities in society to reduce CO_2 emissions had also included. The further part in this chapter is limitation of the study which consist of weaknesses that occurred in this study. Next, the following part of Chapter 5 will be recommendations for future researcher that cover the suggestions for future researcher that willing to further conduct their study on this topic.

5.1 Discussions of Major Findings

Table 5.1

Summarized result of model estimation analysis

	POLS	**FEM**	**REM**
C	-2.504577 (0.1088)	12.76539 *** (0.0000)	-2.504577 *** (0.0000)
LNGDP	0.717110 *** (0.0000)	0.196485 *** (0.0000)	0.717110 *** (0.0000)
LNFDI	0.064732 (0.1826)	0.001781 (0.8913)	0.064732 *** (0.0000)
LNDCTPS	0.371741 *** (0.0000)	0.235293 *** (0.0068)	0.371741 *** (0.0000)
ICT	-0.008886 *** (0.0002)	0.003749 *** (0.0052)	-0.008886 *** (0.0000)

Note: The asterisk denotes the series is significant at the respective significance level, * for 10%, ** for 5% and *** for 1%.

Table 5.2

Summarized result of model selection analysis

Analysis	**P-value**	**Result**
Likelihood Ratio Test	0.0000 ***	FEM is more favourable.
Breusch-Pagan Lagrange Multiplier Test	0.0000 ***	REM is more favourable.
Hausman Test	0.0000 ***	FEM is more favourable.

Note: The asterisk denotes the series is significant at the respective significance level, * for 10%, ** for 5% and *** for 1%.

This study aims to investigate the relationship between CO_2 emissions and combination of four independent variables which are GDP, FDI Inflows, DCTPS and individuals using the internet. FEM will include dummy variable to differentiate every country while POLS will pool all of the data regardless of the country. However, refer to Table 5.1, the result obtained from POLS and FEM are similar where LNGDP, LNDCTPS and ICT are significantly affect the LNCO2. This is attributable to the countries that we had examined in our research are all developing countries and having similar condition in poverty level, education level, economic condition, etc.

Although we had estimated the model using three approaches, but this study will follow the result of FEM as it is the most preferred model and fits the model better. We believe that there are some independent variables that are ommited which have correlation with the variables in the model this is where FEM can provide means in controlling the omitted variable bias.

First of all, according to Table 5.1, the null hypothesis in Section 2.4.1 is rejected at significance level of 1%, 5% and 10%, where the GDP is discovered to have significant and positive impact with CO_2 emissions under the estimation of FEM. The result is consistent with Kizilkaya (2017), Islam, Abdul Ghani, and Mahyudin

(2017), Farhani and Ozturk (2015) and Ali et al. (2019). The result is consistent with those researchers as the scope of study is almost similar where it is also developing countries. When a country is at a developing stage, the economic activity in the country will increase further lead to emissions of GHG or environmental damage.

The result of relationship between GDP and CO_2 emissions in this study is inconsistent with Al-Mulali, Tang, and Ozturk (2015), Ozturk and Acaravci (2013), Kaya, Kayalica, Kumas, and Ulengin (2017) and Arouri, Youssef, M'henni and Rault (2012) that proposed an inverted-U shape relationship between two variables. It is not consistent with Park, Meng and Baloch (2018) that found a negative relationship between two variables. Tsaurai (2019) proposed a significant positive relationship under POLS estimation and insignificant relationship under FEM and REM estimation. Therefore, the result is also inconsistent with Tsaurai (2019). Lastly, it is partially consistent with Omri, Nguyen, and Rault (2014) as the researchers found that positive relationship exists in Middle East, North Africa, and sub-Sahara analysis while insignificant relationship exists for global analysis, Latin America and Caribbean analysis, Europe and North Asia analysis.

Furthermore, according to the Table 5.1, the null hypothesis in Section 2.4.2 is not rejected, where the FDI Inflows is not significantly related with CO_2 emissions in this study. The outcome is similar with the previous study done by Tsaurai (2019) that proposed an insignificant relationship between two variables through FEM estimation. This indicate that FDI Inflows will not significantly affect the environment standard in selected ASEAN-5 countries. The result is partially consistent with Omri et al. (2014) as it proposed an insignificant relationship in Europe and North Asia analysis and positive relationship in other areas. In addition, the result of this study is inconsistent with Kılıçarslan and Dumrul (2017) that proposed a positive relationship between two variables. The result also not consistent with Kaya et al. (2017) as the research found that negative relationship exists in short run and positive relationship exists in long run between two variables in Turkey.

Moreover, according to the Table 5.1, null hypothesis in Section 2.4.3 is rejected at significant level of 1%, 5% and 10%, where the DCTPS is positive and significantly related to CO_2 emissions. The result is consistent with Farhani and Ozturk (2015) and Ali et al. (2019) that found a positive relationship in Tunisia and Nigeria respectively. This indicates that financial development will contribute a significant impact to environmental degradation in selected ASEAN-5 countries as the financial development plays an important role in promoting the economic activities of a country, the economic activities such as production will further lead to emissions of GHG such as CO_2. However, the result of this study is not consistent with the result of Park et al. (2018) and Al-Mulali et al. (2015) that proposed a negative relationship between two variables in European Union and Latin America and Caribbean countries respectively. It is also inconsistent with the result of Ozturk and Acaravci (2013) in Turkey and Tsaurai (2019) that discovered an insignificant relationship between two variables in West Africa under FEM estimation.

Besides that, according to Table 5.1, the null hypothesis in Section 2.4.4 is rejected at significance level of 1%, 5% and 10%. This result revealed that individuals using the internet has a significant positive relationship against CO_2 emissions. The result is inconsistent with Tsaurai (2019) in West Africa under FEM estimation while consistent with Park et al. (2018) in European Union. This is attributable to the human activities using internet such as powering the technology devices, production and the used of internet server during businesses and economic activities as well as the daily life. This series of action will lead to the emissions of GHG such as CO_2, therefore the positive relationship is captured between two variables.

Other than that, we found that the result of our study does not support the theories discussed in Chapter 2 which are EKC Hypothesis and Pollution Haven Hypothesis. EKC Hypothesis claim that the relationship between environmental standard and economic growth will be an inverted-U shape. This theory is applicable to GDP, DCTPS as well as individuals using the internet that related to the economic growth of a nation. Based on the result of this study, these three variables are found to be positively related to CO_2 emissions instead of having inverted-U shape relationship. The inconsistent result is attributable to the economic condition of selected

ASEAN-5 countries that still at the developing stage which is only the first half part of EKC Hypothesis. The environment will keep degraded when the countries is in developing stage and experienced a growth of economy. However, the relationship might follow EKC Hypothesis after the nation is developed, the citizen will start to realize the importance of environment and take an action to protect the environment.

The Pollution Haven Hypothesis claim that the environment policy in developing country will be relatively weaker and loosen as compared to developed country. FDI will stimulate the growth of an economy and further lead to environmental degradation, the company will need to bear a higher environmental cost if they operate in country with strict environmental policy. In other words, FDI Inflows will encourage setup of new business or expansion of existing business that will lead to more economic activities as well as more CO_2 emissions. However, our result shows that FDI Inflows is insignificantly related to CO_2 emissions, this is because investment to ASEAN countries is majority goes to services sector that contributed less CO_2 emissions as compared to manufacturing industry. This is evidenced by the ASEAN Investment Report 2019 where the report stated that services sector such as healthcare and financial services had accounted approximately 66% of FDI Inflows to ASEAN countries from 2014 to 2018 (United Nations Conference on Trade and Development, 2019).

In short, GDP, DCTPS and individuals using the internet is found to be significant affect the CO_2 emissions in selected ASEAN-5 countries. The vary of result as compared to past studies and theories is attributable to different methodologies employed, different scope of study as well as different environment and economy condition in every single country.

5.2 Implications of the Study

Our research had provided benefit to the society, industry and policymakers such as government because our research could help to identify the factors that caused an increase in the CO_2 emissions. By having a clear view regarding the factors that contributed to CO_2 emissions, policymakers and industry could generate more specific solutions to reduce the impact that generate by those factors and ease the implementation process to reduce CO_2 emissions. Based on our research, GDP, DCTPS and individuals using the internet are significant in affecting the CO_2 emissions of a country. According to Cox and Cox (2020), CO_2 emissions and GDP was heading towards same direction. Therefore, to minimize the impact that generated by GDP, government should apply restriction such as carbon tax to restrict the economy activity of a country. Dowdey (n.d.). mentioned that high emissions level of CO_2 will lead to a higher carbon tax that paid by a factory. As a result, in order to avoid paying high amount of carbon tax, a factory might reduce their operation hour or production volume that would lead to a declined in the economy activity.

In addition, government are recommended to apply cap and trade to restrict the amount of CO_2 that released by factory. Cap and trade are a type of policy in which government will set a specific amount of CO_2 that can be released by a factory, and penalty will be given to those factories who failed to meet the restricted level. If a factory able to maintain or expand their production level and with a much lower CO_2 emissions level compared to the restricted level set by the government, they are allowed to sell the additional restricted amount of CO_2 to other factories. As a result, the extra income would provide motivation for the factory to increase their production efficiency and thus result in lower CO_2 emissions (Center on Budget and Policy Priorities, 2015).

On the other hand, in this 21^{st} century, most of the factory and company had applied and work on Industry 4.0. It helped them to increase their cost efficiency and enable them to generate higher amount of profit. Therefore, company or factory are recommended to use the profit that generated to invest in green technology that would thus reduce and control their CO_2 emissions level. For example, Kwiatkowski, Polat, Yu, and Johnson (2019) found that Industrial Emissions Control Technology is an effective way for company or factory to maintain and control their CO_2 emissions level. Moreover, the renewable energy technology would result in lower CO_2 emissions level because it is a technique that transform renewable resources like solar, wind and hydro and others to electricity that needed for production. Therefore, company or factory can apply Industrial Emissions Control Technology or Renewable Energy Technology in the production process to reduce CO_2 emissions. Additionally, company or factory should also implement a proper way to handle their waste of production and replace harmful chemical material that needed in production to environmentally friendly material (BC Sustainable Energy Association, n.d.).

The environmental quality has become an important factor in promoting better life. This is because there were environmental issues that happening in the world like natural disaster and climate change which it further affects the whole ecosystem including human life. Thus, it was necessary that the whole community take part in reducing the impact on environmental quality. The environmental awareness should be created since students as they are still in stage of learning. The schools or university could organize event that exhibit the green technology invented by students or researchers as to get attention of businessman that interested to invest in green technology. Gray (2017) found that researchers at University of Surrey has discovered a supercapacitor which could be used for electric cars. The supercapacitor is believed to let the car travel for six to eight hours without the need to stop for recharging purpose and the charging time is expected to be same as the time spent on filling the car with petrol. Therefore, the electric car can be used to replace the car that used petrol in order to reduce CO_2 emissions since the burning of petrol emit CO_2 into the atmosphere.

5.3 Limitations of the Study

In our research study, we found that one of the limitations is the lack of time period data. Our data only uses the time period from 2004 to 2017 which is considered less where the data mostly obtained from WDI. The countries that we used are also limited to the selected ASEAN-5 in which we only include developing countries in our research. Developing countries often vary and highly depends on the advancement of technologies which is the factor that considered as significant in determine the level of CO_2 emissions. During our research process, countries are our main focus rather than industry, so it was harder to specify which area of the country that contribute to the emissions of the CO_2. The energy consumption of these industries in different area of the country produce different level of CO_2 especially industrialization area which demand higher consumption of energy lead to higher CO_2 emissions.

5.4 Recommendations for Future Research

For future researcher that study the similar topic which is the CO_2 emissions, we suggest to focus more on specific area or industry of the country. This can help the government to identify and control the level of CO_2 emissions from those area easily rather than focused on the whole country which is harder for them to pinpoint the problems. There were countries that have incomplete data compare to other countries which makes the research of the country becomes difficult. As WDI is one of the main sources for data collection, it is better that WDI can have more data to help future researchers in their study. Other than that, future researchers should focus more on the study of CO_2 emissions to bring awareness to the government and public on how it greatly impacts the environment. For example, open burning and deforestation from countries such as Indonesia leads to the degradation of environment, worsen the haze level and affect the health condition and quality of life of the resident in Southeast Asia. In our research study, the variables that were significant are GDP, DCTPS and individuals using the internet. We suggest that the future researcher can increase the number of countries and variables to find more variables that are consider important in affecting the CO_2 emissions.

5.5 Conclusion

Our research had captured the effect of the factors that contributed to environmental degradation in selected ASEAN-5 countries. According to our result, we found that

GDP, DCTPS, and individuals using the internet are significant in affecting the CO_2 emissions in the selected ASEAN-5 countries within the sample period from 2004 to 2017. We had suggested several ways to reduce CO_2 emissions such as implementation of carbon tax, cap and trade, green technology, proper way to handle their waste of production, replace harmful chemical material that needed in the production process and increase the environmental awareness of the students. In a nutshell, our research could increase the society’s attention, awareness and enthusiasm of finding the solution to address the current environmental issue.

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APPENDICES

Appendix 4.1: Descriptive Analysis

Date: 08/21/20 Time: 22:19
Sample: 1 70

	LNCO2	LNGDP	LNFDI	LNDCTPS	ICT
Mean	19.07566	26.27466	22.54817	4.200290	31.80274
Median	19.19160	26.32967	22.83013	4.546796	27.74500
Maximum	20.18554	27.64652	23.94696	5.006449	80.14048
Minimum	18.01304	24.53939	18.55752	3.202992	2.600286
Std. Dev.	0.581476	0.683427	0.929697	0.624668	20.85874
Skewness	-0.064234	-0.051239	-1.481841	-0.339867	0.409214
Kurtosis	2.136274	3.015708	6.598074	1.423893	2.103445
Jarque-Bera	2.224035	0.031350	63.37785	8.592940	4.298099
Probability	0.328895	0.984447	0.000000	0.013617	0.116595
Sum	1335.296	1839.226	1578.372	294.0203	2226.192
Sum Sq. Dev.	23.32992	32.22803	59.63916	26.92448	30021.02
Observations	70	70	70	70	70

Appendix 4.2: LLC Test for LNCO2 at Level Form (Individual Intercept)

Levin, Lin & Chu Unit Root Test on LNCO2

Null Hypothesis: Unit root (common unit root process)
Series: LNCO2
Date: 08/21/20 Time: 22:40
Sample: 2004 2017
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 2
Newey-West automatic bandwidth selection and Bartlett kernel
Total number of observations: 60
Cross-sections included: 5

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-0.46977	0.3193

** Probabilities are computed assuming asympotic normality

Intermediate results on LNCO2

Cross section	2nd Stage Coefficient	Variance of Reg	HAC of Dep.	Lag	Max Lag	Band-width	Obs
Indonesia	-0.26147	0.0152	0.0022	0	2	12.0	13
Malaysia	-0.14803	0.0008	0.0003	2	2	8.0	11
Philippines	0.16492	0.0024	0.0029	1	2	0.0	12
Thailand	-0.07963	0.0007	0.0002	0	2	12.0	13
Vietnam	-0.04329	0.0019	0.0005	2	2	12.0	11
	Coefficient	t-Stat	SE Reg	mu*	sig*		Obs
Pooled	-0.04976	-1.190	1.061	-0.554	0.919		60

Appendix 4.3: LLC Test for LNCO2 at Level Form (Individual Intercept and Trend)

Levin, Lin & Chu Unit Root Test on LNCO2

Null Hypothesis: Unit root (common unit root process)
Series: LNCO2
Date: 08/21/20 Time: 22:40
Sample: 2004 2017
Exogenous variables: Individual effects, individual linear trends
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 1
Newey-West automatic bandwidth selection and Bartlett kernel
Total number of observations: 63
Cross-sections included: 5

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-4.84311	0.0000

** Probabilities are computed assuming asympotic normality

Intermediate results on LNCO2

Cross section	2nd Stage Coefficient	Variance of Reg	HAC of Dep.	Lag	Max Lag	Band-width	Obs
Indonesia	-1.10646	0.0080	0.0022	1	1	12.0	12
Malaysia	-1.24113	0.0008	0.0002	0	1	7.0	13
Philippines	-0.40189	0.0014	0.0002	0	1	12.0	13
Thailand	-0.55726	0.0006	0.0001	0	1	12.0	13
Vietnam	-1.20545	0.0010	0.0003	1	1	12.0	12
	Coefficient	t-Stat	SE Reg	mu*	sig*		Obs
Pooled	-0.79510	-6.799	1.093	-0.703	1.003		63

Appendix 4.4: LLC Test for LNGDP at Level Form (Individual Intercept)

Levin, Lin & Chu Unit Root Test on LNGDP

Null Hypothesis: Unit root (common unit root process)
Series: LNGDP
Date: 08/21/20 Time: 22:42
Sample: 2004 2017
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0 to 2
Newey-West automatic bandwidth selection and Bartlett kernel
Total number of observations: 63
Cross-sections included: 5

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-6.48179	0.0000

** Probabilities are computed assuming asympotic normality

Intermediate results on LNGDP

Cross section	2nd Stage Coefficient	Variance of Reg	HAC of Dep.	Lag	Max Lag	Band-width	Obs
Indonesia	-0.13411	0.0072	0.0176	0	2	2.0	13
Malaysia	-0.19045	0.0075	0.0113	0	2	0.0	13
Philippines	-0.11156	0.0024	0.0053	0	2	1.0	13
Thailand	-0.13661	0.0033	0.0059	0	2	1.0	13
Vietnam	-0.19620	0.0009	0.0049	2	2	1.0	11
	Coefficient	t-Stat	SE Reg	mu*	sig*		Obs
Pooled	-0.14723	-7.010	1.024	-0.554	0.919		63

Appendix 4.5: LLC Test for LNGDP at Level Form (Individual Intercept and Trend)

Levin, Lin & Chu Unit Root Test on LNGDP

Null Hypothesis: Unit root (common unit root process)
Series: LNGDP
Date: 08/21/20 Time: 22:42
Sample: 2004 2017
Exogenous variables: Individual effects, individual linear trends
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0
Newey-West automatic bandwidth selection and Bartlett kernel
Total (balanced) observations: 65
Cross-sections included: 5

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-1.41100	0.0791

** Probabilities are computed assuming asympotic normality

Intermediate results on LNGDP

Cross section	2nd Stage Coefficient	Variance of Reg	HAC of Dep.	Lag	Max Lag	Band-width	Obs
Indonesia	-0.13923	0.0072	0.0072	0	1	2.0	13
Malaysia	-0.28099	0.0074	0.0008	0	1	10.0	13
Philippines	-0.15464	0.0024	0.0002	0	1	12.0	13
Thailand	-0.25753	0.0032	0.0004	0	1	12.0	13
Vietnam	-0.22824	0.0016	0.0003	0	1	7.0	13
	Coefficient	t-Stat	SE Reg	mu*	sig*		Obs
Pooled	-0.20685	-2.948	1.005	-0.703	1.003		65

Appendix 4.6: LLC Test for LNFDI at Level Form (Individual Intercept)

Levin, Lin & Chu Unit Root Test on LNFDI

Null Hypothesis: Unit root (common unit root process)
Series: LNFDI
Date: 08/21/20 Time: 22:43
Sample: 2004 2017
Exogenous variables: Individual effects
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0
Newey-West automatic bandwidth selection and Bartlett kernel
Total (balanced) observations: 65
Cross-sections included: 5

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-3.84777	0.0001

** Probabilities are computed assuming asympotic normality

Intermediate results on LNFDI

Cross section	2nd Stage Coefficient	Variance of Reg	HAC of Dep.	Lag	Max Lag	Band-width	Obs
Indonesia	-0.71098	0.3528	0.1581	0	2	10.0	13
Malaysia	-1.02849	1.4735	0.2089	0	2	12.0	13
Philippines	-0.28067	0.1859	0.1903	0	2	1.0	13
Thailand	-1.43267	0.2381	0.0509	0	2	12.0	13
Vietnam	-0.22894	0.0586	0.0978	0	2	1.0	13
	Coefficient	t-Stat	SE Reg	mu*	sig*		Obs
Pooled	-0.46085	-5.238	1.192	-0.554	0.919		65

Appendix 4.7: LLC Test for LNFDI at Level Form (Individual Intercept and Trend)

Levin, Lin & Chu Unit Root Test on LNFDI

Null Hypothesis: Unit root (common unit root process)
Series: LNFDI
Date: 08/21/20 Time: 22:44
Sample: 2004 2017
Exogenous variables: Individual effects, individual linear trends
Automatic selection of maximum lags
Automatic lag length selection based on SIC: 0
Newey-West automatic bandwidth selection and Bartlett kernel
Total (balanced) observations: 65
Cross-sections included: 5

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-4.57772	0.0000

** Probabilities are computed assuming asympotic normality

Intermediate results on LNFDI

Cross section	2nd Stage Coefficient	Variance of Reg	HAC of Dep.	Lag	Max Lag	Band-width	Obs
Indonesia	-0.93692	0.2985	0.0520	0	1	12.0	13
Malaysia	-1.13936	1.3066	0.2091	0	1	12.0	13
Philippines	-0.66984	0.1429	0.1918	0	1	1.0	13
Thailand	-1.48392	0.2131	0.0491	0	1	12.0	13
Vietnam	-0.38189	0.0546	0.0358	0	1	5.0	13
	Coefficient	t-Stat	SE Reg	mu*	sig*		Obs
Pooled	-0.84813	-7.373	1.111	-0.703	1.003		65

Appendix 4.8: LLC Test for LNDCTPS at Level Form (Individual Intercept)

Levin, Lin & Chu Unit Root Test on LNDCTPS

Null Hypothesis: Unit root (common unit root process)
Series: LNDCTPS
Date: 08/21/20 Time: 22:45
Sample: 2004 2017
Exogenous variables: Individual effects
User-specified maximum lags
Automatic lag length selection based on SIC: 0 to 4
Newey-West automatic bandwidth selection and Bartlett kernel
Total number of observations: 54
Cross-sections included: 5

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-8.53832	0.0000

** Probabilities are computed assuming asympotic normality

Intermediate results on LNDCTPS

Cross section	2nd Stage Coefficient	Variance of Reg	HAC of Dep.	Lag	Max Lag	Band-width	Obs
Indonesia	-0.53037	0.0002	0.0024	4	4	0.0	9
Malaysia	-0.23853	0.0024	0.0022	0	4	1.0	13
Philippines	0.70587	0.0040	0.0130	2	4	1.0	11
Thailand	-0.25529	9.E-05	0.0024	4	4	3.0	9
Vietnam	-0.25239	0.0086	0.0104	1	4	1.0	12
	Coefficient	t-Stat	SE Reg	mu*	sig*		Obs
Pooled	-0.28770	-9.140	1.302	-0.554	0.919		54

Appendix 4.9: LLC Test for LNDCTPS at Level Form (Individual Intercept and Trend)

Levin, Lin & Chu Unit Root Test on LNDCTPS

Null Hypothesis: Unit root (common unit root process)
Series: LNDCTPS
Date: 08/21/20 Time: 22:46
Sample: 2004 2017
Exogenous variables: Individual effects, individual linear trends
User-specified maximum lags
Automatic lag length selection based on SIC: 0 to 4
Newey-West automatic bandwidth selection and Bartlett kernel
Total number of observations: 51
Cross-sections included: 5

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-21.6662	0.0000

** Probabilities are computed assuming asympotic normality

Intermediate results on LNDCTPS

Cross section	2nd Stage Coefficient	Variance of Reg	HAC of Dep.	Lag	Max Lag	Band-width	Obs
Indonesia	-1.04672	7.E-05	0.0022	4	4	0.0	9
Malaysia	-0.73059	0.0014	0.0019	0	4	2.0	13
Philippines	0.06488	0.0030	0.0025	2	4	4.0	11
Thailand	-1.10603	2.E-05	0.0024	4	4	4.0	9
Vietnam	-1.71334	3.E-05	0.0098	4	4	1.0	9
	Coefficient	t-Stat	SE Reg	mu*	sig*		Obs
Pooled	-1.58262	-28.113	1.543	-0.703	1.003		51

Appendix 4.10: LLC Test for ICT at Level Form (Individual Intercept)

Levin, Lin & Chu Unit Root Test on ICT

Null Hypothesis: Unit root (common unit root process)
Series: ICT
Date: 08/21/20 Time: 22:47
Sample: 2004 2017
Exogenous variables: Individual effects
User-specified maximum lags
Automatic lag length selection based on SIC: 0 to 4
Newey-West automatic bandwidth selection and Bartlett kernel
Total number of observations: 57
Cross-sections included: 5

Method	Statistic	Prob.**
Levin, Lin & Chu t*	4.18746	1.0000

** Probabilities are computed assuming asympotic normality

Intermediate results on ICT

Cross section	2nd Stage Coefficient	Variance of Reg	HAC of Dep.	Lag	Max Lag	Band-width	Obs
Indonesia	0.29219	1.8086	5.3211	1	4	2.0	12
Malaysia	-0.07396	17.804	7.7559	0	4	6.0	13
Philippines	-0.01748	63.757	15.626	0	4	10.0	13
Thailand	0.62469	0.9263	10.198	3	4	2.0	10
Vietnam	-0.14595	0.9094	2.6384	4	4	0.0	9
	Coefficient	t-Stat	SE Reg	mu*	sig*		Obs
Pooled	0.12954	2.327	1.327	-0.554	0.919		57

Appendix 4.11: LLC Test for ICT at Level Form (Individual Intercept and Trend)

Levin, Lin & Chu Unit Root Test on ICT

Null Hypothesis: Unit root (common unit root process)
Series: ICT
Date: 08/21/20 Time: 22:48
Sample: 2004 2017
Exogenous variables: Individual effects, individual linear trends
User-specified maximum lags
Automatic lag length selection based on SIC: 0 to 4
Newey-West automatic bandwidth selection and Bartlett kernel
Total number of observations: 56
Cross-sections included: 5

Method	Statistic	Prob.**
Levin, Lin & Chu t*	-7.91027	0.0000

** Probabilities are computed assuming asympotic normality

Intermediate results on ICT

Cross section	2nd Stage Coefficient	Variance of Reg	HAC of Dep.	Lag	Max Lag	Band-width	Obs
Indonesia	0.18254	2.1765	1.6507	0	4	1.0	13
Malaysia	-0.62999	12.861	6.1091	0	4	7.0	13
Philippines	-3.61422	0.3456	7.1252	4	4	12.0	9
Thailand	0.10902	2.6892	4.4429	1	4	2.0	12
Vietnam	-2.60290	0.1690	2.5618	4	4	0.0	9
	Coefficient	t-Stat	SE Reg	mu*	sig*		Obs
Pooled	-2.43427	-10.375	2.896	-0.703	1.003		56

Appendix 4.12: Pooled Ordinary Least Squares

Dependent Variable: LNCO2
Method: Panel Least Squares
Date: 08/21/20 Time: 22:50
Sample: 2004 2017
Periods included: 14
Cross-sections included: 5
Total panel (balanced) observations: 70

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.504577	1.540229	-1.626107	0.1088
LNGDP	0.717110	0.066389	10.80159	0.0000
LNFDI	0.064732	0.048049	1.347199	0.1826
LNDCTPS	0.371741	0.080717	4.605499	0.0000
ICT	-0.008886	0.002258	-3.935861	0.0002

Root MSE	0.285928	R-squared	0.754700
Mean dependent var	19.07566	Adjusted R-squared	0.739605
S.D. dependent var	0.581476	S.E. of regression	0.296721
Akaike info criterion	0.476701	Sum squared resid	5.722822
Schwarz criterion	0.637308	Log likelihood	-11.68453
Hannan-Quinn criter.	0.540496	F-statistic	49.99550
Durbin-Watson stat	0.187397	Prob(F-statistic)	0.000000

Appendix 4.13: Fixed Effects Model

Dependent Variable: LNCO2
Method: Panel Least Squares
Date: 08/21/20 Time: 22:51
Sample: 2004 2017
Periods included: 14
Cross-sections included: 5
Total panel (balanced) observations: 70

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	12.76539	0.991228	12.87836	0.0000
LNGDP	0.196485	0.043878	4.477957	0.0000
LNFDI	0.001781	0.012976	0.137287	0.8913
LNDCTPS	0.235293	0.083969	2.802148	0.0068
ICT	0.003749	0.001292	2.901593	0.0052

Effects Specification

Cross-section fixed (dummy variables)

Root MSE	0.066814	R-squared	0.986606
Mean dependent var	19.07566	Adjusted R-squared	0.984849
S.D. dependent var	0.581476	S.E. of regression	0.071573
Akaike info criterion	-2.316667	Sum squared resid	0.312487
Schwarz criterion	-2.027575	Log likelihood	90.08335
Hannan-Quinn criter.	-2.201836	F-statistic	561.6484
Durbin-Watson stat	1.188473	Prob(F-statistic)	0.000000

Appendix 4.14: Random Effects Model

Dependent Variable: LNCO2
Method: Panel EGLS (Cross-section random effects)
Date: 08/21/20 Time: 22:53
Sample: 2004 2017
Periods included: 14
Cross-sections included: 5
Total panel (balanced) observations: 70
Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.504577	0.371525	-6.741342	0.0000
LNGDP	0.717110	0.016014	44.78008	0.0000
LNFDI	0.064732	0.011590	5.585074	0.0000
LNDCTPS	0.371741	0.019470	19.09299	0.0000
ICT	-0.008886	0.000545	-16.31688	0.0000

Effects Specification

	S.D.	Rho
Cross-section random	5.36E-07	0.0000
Idiosyncratic random	0.071573	1.0000

Weighted Statistics

Root MSE	0.285928	R-squared	0.754700
Mean dependent var	19.07566	Adjusted R-squared	0.739605
S.D. dependent var	0.581476	S.E. of regression	0.296721
Sum squared resid	5.722822	F-statistic	49.99550
Durbin-Watson stat	0.187397	Prob(F-statistic)	0.000000

Unweighted Statistics

R-squared	0.754700	Mean dependent var	19.07566
Sum squared resid	5.722822	Durbin-Watson stat	0.187397

Appendix 4.15: Likelihood Ratio Test

Redundant Fixed Effects Tests
Equation: Untitled
Test cross-section fixed effects

Effects Test	Statistic	d.f.	Prob.
Cross-section F	264.035164	(4,61)	0.0000
Cross-section Chi-square	203.535770	4	0.0000

Cross-section fixed effects test equation:
Dependent Variable: LNCO2
Method: Panel Least Squares
Date: 08/21/20 Time: 22:54
Sample: 2004 2017
Periods included: 14
Cross-sections included: 5
Total panel (balanced) observations: 70

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.504577	1.540229	-1.626107	0.1088
LNGDP	0.717110	0.066389	10.80159	0.0000
LNFDI	0.064732	0.048049	1.347199	0.1826
LNDCTPS	0.371741	0.080717	4.605499	0.0000
ICT	-0.008886	0.002258	-3.935861	0.0002

Root MSE	0.285928	R-squared	0.754700
Mean dependent var	19.07566	Adjusted R-squared	0.739605
S.D. dependent var	0.581476	S.E. of regression	0.296721
Akaike info criterion	0.476701	Sum squared resid	5.722822
Schwarz criterion	0.637308	Log likelihood	-11.68453
Hannan-Quinn criter.	0.540496	F-statistic	49.99550
Durbin-Watson stat	0.187397	Prob(F-statistic)	0.000000

Appendix 4.16: Breusch-Pagan Lagrange Multiplier Test

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

	Test Hypothesis		
	Cross-section	Time	Both
Breusch-Pagan	183.5847 (0.0000)	0.179126 (0.6721)	183.7638 (0.0000)
Honda	13.54934 (0.0000)	0.423232 (0.3361)	9.880102 (0.0000)
King-Wu	13.54934 (0.0000)	0.423232 (0.3361)	12.05385 (0.0000)
Standardized Honda	27.86675 (0.0000)	0.636263 (0.2623)	9.654671 (0.0000)
Standardized King-Wu	27.86675 (0.0000)	0.636263 (0.2623)	15.59642 (0.0000)
Gourieroux, et al.*	--	--	183.7638 (0.0000)

Appendix 4.17: Hausman Test

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

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	1056.140657	4	0.0000

Cross-section random effects test comparisons:

Variable	Fixed	Random	Var(Diff.)	Prob.
LNGDP	0.196485	0.717110	0.001669	0.0000
LNFDI	0.001781	0.064732	0.000034	0.0000
LNDCTPS	0.235293	0.371741	0.006672	0.0948
ICT	0.003749	-0.008886	0.000001	0.0000

Cross-section random effects test equation:
Dependent Variable: LNCO2
Method: Panel Least Squares
Date: 08/21/20 Time: 22:55
Sample: 2004 2017
Periods included: 14
Cross-sections included: 5
Total panel (balanced) observations: 70

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	12.76539	0.991228	12.87836	0.0000
LNGDP	0.196485	0.043878	4.477957	0.0000
LNFDI	0.001781	0.012976	0.137287	0.8913
LNDCTPS	0.235293	0.083969	2.802148	0.0068
ICT	0.003749	0.001292	2.901593	0.0052

Effects Specification

Cross-section fixed (dummy variables)

Root MSE	0.066814	R-squared	0.986606
Mean dependent var	19.07566	Adjusted R-squared	0.984849
S.D. dependent var	0.581476	S.E. of regression	0.071573
Akaike info criterion	-2.316667	Sum squared resid	0.312487
Schwarz criterion	-2.027575	Log likelihood	90.08335
Hannan-Quinn criter.	-2.201836	F-statistic	561.6484
Durbin-Watson stat	1.188473	Prob(F-statistic)	0.000000

Appendix 4.18: Pairwise-Correlation Analysis

Correlation

	LNCO2	LNGDP	LNFDI	LNDCTPS	ICT
LNCO2	1.000000	0.799995	0.547636	0.062085	0.003270
LNGDP	0.799995	1.000000	0.504465	-0.190979	0.058945
LNFDI	0.547636	0.504465	1.000000	0.222189	0.218903
LNDCT	0.062085	-0.190979	0.222189	1.000000	0.625237
ICT	0.003270	0.058945	0.218903	0.625237	1.000000

Appendix 4.19: Variance Inflation Factor

Variance Inflation Factors
Date: 08/21/20 Time: 22:30
Sample: 1 70
Included observations: 70

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
LNGDP	0.004408	2420.816	1.613370
LNFDI	0.002309	934.8131	1.563898
LNDCTPS	0.006515	93.38019	1.992411
ICT	5.10E-06	5.836903	1.738045
C	2.372306	1886.131	NA

Appendix 4.20: R_j^2 for LNGDP

Dependent Variable: LNGDP
Method: Panel Least Squares
Date: 08/24/20 Time: 12:24
Sample: 2004 2017
Periods included: 14
Cross-sections included: 5
Total panel (balanced) observations: 70

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNFDI	0.409319	0.073471	5.571134	0.0000
LNDCTPS	-0.494588	0.136713	-3.617699	0.0006
ICT	0.007199	0.004091	1.759550	0.0831
C	18.89374	1.657234	11.40077	0.0000

Root MSE	0.534196	R-squared	0.380179
Mean dependent var	26.27466	Adjusted R-squared	0.352006
S.D. dependent var	0.683427	S.E. of regression	0.550146
Akaike info criterion	1.698179	Sum squared resid	19.97560
Schwarz criterion	1.826665	Log likelihood	-55.43628
Hannan-Quinn criter.	1.749215	F-statistic	13.49413
Durbin-Watson stat	0.516649	Prob(F-statistic)	0.000001

Appendix 4.21: R_j^2 for LNFDI

Dependent Variable: LNFDI
Method: Panel Least Squares
Date: 08/24/20 Time: 12:24
Sample: 2004 2017
Periods included: 14
Cross-sections included: 5
Total panel (balanced) observations: 70

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNGDP	0.781421	0.140263	5.571134	0.0000
LNDCTPS	0.528285	0.196287	2.691384	0.0090
ICT	-0.001644	0.005780	-0.284455	0.7770
C	-0.150068	3.945679	-0.038034	0.9698

Root MSE	0.738095	R-squared	0.360572
Mean dependent var	22.54817	Adjusted R-squared	0.331507
S.D. dependent var	0.929697	S.E. of regression	0.760133
Akaike info criterion	2.344799	Sum squared resid	38.13495
Schwarz criterion	2.473284	Log likelihood	-78.06795
Hannan-Quinn criter.	2.395835	F-statistic	12.40575
Durbin-Watson stat	1.702406	Prob(F-statistic)	0.000002

Appendix 4.22: R_j^2 for LNDCTPS

Dependent Variable: LNDCTPS
Method: Panel Least Squares
Date: 08/24/20 Time: 12:25
Sample: 2004 2017
Periods included: 14
Cross-sections included: 5
Total panel (balanced) observations: 70

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNGDP	-0.334589	0.092487	-3.617699	0.0006
LNFDI	0.187203	0.069557	2.691384	0.0090
ICT	0.017544	0.002681	6.542657	0.0000
C	8.212469	2.120154	3.873525	0.0002

Root MSE	0.439375	R-squared	0.498095
Mean dependent var	4.200290	Adjusted R-squared	0.475282
S.D. dependent var	0.624668	S.E. of regression	0.452493
Akaike info criterion	1.307358	Sum squared resid	13.51352
Schwarz criterion	1.435844	Log likelihood	-41.75754
Hannan-Quinn criter.	1.358394	F-statistic	21.83304
Durbin-Watson stat	0.237236	Prob(F-statistic)	0.000000

Appendix 4.23: R_j^2 for ICT

Dependent Variable: ICT
Method: Panel Least Squares
Date: 08/24/20 Time: 12:25
Sample: 2004 2017
Periods included: 14
Cross-sections included: 5
Total panel (balanced) observations: 70

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNGDP	6.224542	3.537575	1.759550	0.0831
LNFDI	-0.744725	2.618078	-0.284455	0.7770
LNDCTPS	22.42461	3.427447	6.542657	0.0000
C	-209.1426	79.93103	-2.616539	0.0110

Root MSE	15.70844	R-squared	0.424641
Mean dependent var	31.80274	Adjusted R-squared	0.398488
S.D. dependent var	20.85874	S.E. of regression	16.17746
Akaike info criterion	8.460560	Sum squared resid	17272.86
Schwarz criterion	8.589045	Log likelihood	-292.1196
Hannan-Quinn criter.	8.511596	F-statistic	16.23700
Durbin-Watson stat	0.106567	Prob(F-statistic)	0.000000