Univerzita Palackého v Olomouci

Université Clermont Auvergne

Università Degli Studi di Pavia

MASTER THESIS

Annisa Caesara HIDAYATI

Supervisor:
Pascale COMBES-MOTEL, Ph. D.

GLODEP 2019

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Environmental Kuznets Curve and the Impact of Energy Consumption, Institution, and Foreign Direct Investment on CO_2 Emissions in ASEAN

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Centre d'"Études et de Recherches sur le Développement International (CERDI)

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UNIVERZITA PALACKÉHO V OLOMOUCI

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ZADÁNÍ DIPLOMOVÉ PRÁCE

(projektu, uměleckého díla, uměleckého výkonu)

Jméno a příjmení:	**Annisa Caesara HIDAYATI**
Osobní číslo:	**R170187**
Studijní program:	**N1301 Geography**
Studijní obor:	**International Development Studies**
Téma práce:	**The Environmental Kuznets Curve in ASEAN-4 Countries (Indonesia, Malaysia, Philippines, and Thailand)**
Zadávající katedra:	**Katedra rozvojových a environmentálních studií**

Zásady pro vypracování

The objective of this study is to test the existence of environmental Kuznets curve (EKC). EKC is an expression coined by Grossman and Krueger (1995), that establishes a non linear relationship between environmental degradation and economic development. In the early stages of development the relationship is positive and becomes negative at higher levels of economic development. The study will focus on ASEAN-4 Countries over the period of 1970-2014. The thesis is structured in three main parts. The first part will be introduction which includes the background, motivation and research questions. The second part is devoted to the theoretical framework and methodology. It provides a literature review, the empirical framework and empirical findings. The last part is the conclusion that summarizes the main findings and possible policy implication. This study will rely on an econometric analysis along with descriptive statistics presenting the main stylized facts on the quality of environment and economic development.

Rozsah pracovní zprávy:	**15000 slov**
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Seznam doporučené literatury:

Acaravci, A., & Ilhan, O. (2010). On the relationship between energy consumption, CO2 emissions and economic growth in Europe. Energy Vol. 35, Issue 12. Grossman, G. M. and Krueger, A. B. (1995) 'Economic Growth and the Environment', The Quarterly Journal of Economics, 110(2), pp. 353-377. doi: 10.2307/2118443. Halicioglu, F. (2009). An econometric study of CO2 emissions, energy consumption, income and foreign trade in Turkey. Energy Policy, Volume 37, Issue 3. Jalil, A., & Mahmud, S. F. (2009). Environment Kuznets curve fo rCO2 emissions: A cointegration analysis for China. Energy Policy. Kwiatkowski, D., Phillips, P. C., Schmidt, P., & Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root? Journal of Econometrics Volume 54. Lahiani, A. (2018). Revisiting the growth-carbon dioxide emissions nexus in Pakistan. Environmental Science and Pollution Research. Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics. Ridzuan, A. R., Noor, A. H., & Ahmed, E. M. (2014). The Impact of Foreign Direct Investment towards Carbon Dioxide Level: Pollution Havens Model for ASEAN5 Countries. Asian Journal of Agricultural Extension, Economics & Sociology.

Vedoucí diplomové práce:	**prof. Pascale Combes Motel** University of Clermont Auvergne
Datum zadání diplomové práce:	**31. ledna 2019**
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V Olomouci dne 31. ledna 2019

L.S.

doc. RNDr. Martin Kubala, Ph.D.
děkan

doc. RNDr. Pavel Nováček, CSc.
vedoucí katedry

Declaration

Hereby, I declare in lieu of oath that this master thesis focused on the title: "Environmental Kuznets Curve and The Impact of Energy Consumption, Institution, and Foreign Direct Investment on CO2 Emissions in ASEAN" was written by myself under the professional supervision of Professor Pascale COMBES-MOTEL, Ph. D. All information derived from the work of others has been acknowledged in the text and the list of references is given.

Clermont-Ferrand, 28th May, 2019 ……………………………………………..

Signature

Annulment

The title of the thesis is changed from "The Environmental Kuznets Curve in ASEAN-4 (Indonesia, Malaysia, Philippines, and Thailand)" to "Environmental Kuznets Curve and The Impact of Energy Consumption, Institution, and Foreign Direct Investment on CO2 Emissions in ASEAN".

As the model specification and analysis were done simultaneously, the variables and the observations were object to change. Initially the research was aimed to observed the environmental Kuznets curve in four countries (Indonesia, Malaysia, Philippines, Thailand) but then later the author added all of the ASEAN member states (Brunei, Cambodia, Myanmar, Singapore, Lao, and Vietnam) for better variability of the data and to analyze further the region.

Acknowledgement

I would like to express my appreciation for my supervisor, Professor Pascale COMBES-MOTEL for her guidance and supervision and to provide valuable information and suggestion regarding this research.

I would like to thank all the professors of GLODEP in three universities; UniverzitaPalackého v Olomouci in Czech Republic, Université Clermont Auvergne in France, and Università Degli Studi di Pavia in Italy for the knowledge and expertise. Also, thanks to the supporting staffs of GLODEP for the assistance during the study.

I would also like to express my gratitude to my internship supervisor in People in Need, Ana GABROVEC for her supervisory during the internship.

I would like to thank the first cohort of GLODEP particularly Aziz, Shifa, and Romina who had supported me during the study and the writing of the thesis. Thanks to Aryani, Adela, and Francis for the constant encouragement. I am also very much thankful for the support of my family specially my parents, my brother Bramantio, and my sister Shabrina during my study.

As the topic of this thesis is environment, I would embarrass myself not to express my gratitude to the mother nature, the plants, and the animals that remind me to always be aware and conscious of my actions and without them it is impossible for human to exist.

Abstract

This study analyses the effect of economic growth to ASEAN countries on the environment and more specifically test the existence of an Environmental Kuznets Curve. The fixed-effects and panel cointegration models followed by FMOLS and DOLS have been utilized in determining factors that influence carbon dioxide emissions in ASEAN countries (Brunei, Indonesia, Cambodia, Myanmar, Malaysia, Philippines, Singapore, Thailand, Lao, and Vietnam). The results support the environmental Kuznets curve hypothesis. Moreover, energy consumption has significant effect to carbon dioxide while institutional quality and foreign direct investment are insignificant. From the findings it is hoped that it can give useful information of the influence of the variables to the pollution of carbon dioxide in ASEAN.

Keywords: ASEAN, economic growth, environmental degradation, GDP, CO2, energy consumption, FDI, panel data analysis

Contents

List of Figures, Tables, and Abbreviations

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Abbreviations

AIC – Akaike Information Criterion
AECEN – Asian Environmental Compliance and Enforcement Network
ARENELESD – ASEAN Regional Networks of Environmental Law Enforcement for Sustainable Development
ASCC – ASEAN Socio-Cultural Community
AWGMEA – ASEAN Working Group Multilateral Environmental Agreements
CO2 – Carbon Dioxide
CSR – Corporate Social Responsibility
DOLS – Dynamic Ordinary Least Squares
EC – Energy Consumption
EEKC – Energy- Environmental Kuznets Curve
EIA – Environmental Impact Assessment
EKC – Environmental Kuznets Curve
FDI – Foreign Direct Investments
FMOLS – Fully Modified Ordinary Least Squares
GDP – Gross Domestic Products
INT – Institutional quality
IPS – Im, Pesaran, Shin
MEA – Multilateral Environmental Agreements
OLS – Ordinary Least Squares
UNFCCC – United Nations Framework Convention on Climate Chan

1. Introduction

1.1. Background of the Study

It is necessary to put attention on the environmental problem at every level possible including national, regional, and globally for all countries around the world. The center of attraction of policies and regulation nowadays still largely put on the energy use and its factors of implications such as national income, among others. As a result, extensive literatures exist in empirical economics study related to emissions with economic growth and other factors[1]. In most developing countries, attempts to tighten the regulations regarding the emissions face the constraint of the need to economic growth. Furthermore, most nations in the world have target to achieve an appropriate balance among three policy objectives: 1) to achieve the target of sustainable economic growth, 2) to reduce emissions, 3) to strive towards social progress. This study focuses on 2 of those 3 pillars which is the pillars of economy and environment.

The Association of Southeast Asian Nations (ASEAN) member countries altogether has a total GDP of about $2.8 trillion in 2018, and has experienced an increasing of more than fifty percent of GDP per capita from 2007 to 2017 (ASEAN Secretariat, 2017). If it considered a single country, it would be among the top 10 economic powers in the world (Rao, 2018). With over of 600 million inhabitants, ASEAN is also the world's third-largest emerging market. The region also positioned in number three of largest work force, after China and India, and has households' consumer around 67 million, a figure that could almost double to 125 million by 2025 (HV, Thompson, & Tonby, 2014). As ASEAN is a diverse group of nations with different country profiles, it is interesting to conduct a research in this region. Therefore, this study will focus on all the member of ASEAN.

Since the beginning of the 21st century the level of carbon dioxide emissions specifically in East Asia and Pacific has been increasing in an unprecedented speed (see Figure 1) comparing to other region where North America and European Union country group come after East Asia and Pacific region. Middle East & North Africa region shows increasing trend of emitting CO2 although not as excessive as East Asia & Pacific. In a similar manner with Middle East and North Africa, Latin America & Caribbean Region in the case of total carbon dioxide emissions tends to somewhat grow over time. This notion gives the impression that we must pay attention because more people use energy that is

1 Mardani, Streimikiene, Cavallaro, Loganathan, & Khoshnoudi (2018) has an exquisite review of carbon dioxide and economic growth in two decades of research from 1995 to 2017 obtaining 175 articles.

sourced from the fossil fuel, it rises the level of carbon dioxide resulting in climate change. Population growth in Asia triggers energy use that elevate carbon dioxide emissions has putting pressure on the environment. As a result of this issue, Asian countries need to find ways for sustainable development for the long term.

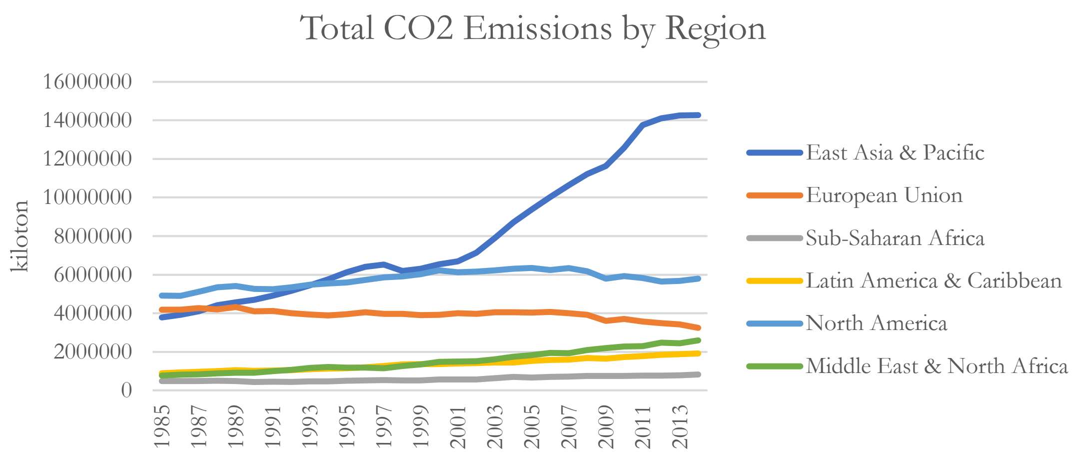


Figure 1. Total Carbon Dioxide Emissions (kiloton) by Region
Source: World Development Indicators (2019)

Based on Figure 2 of CO2 Emissions per Capita by Region, we can see that highest emitter region is North America although they are showing a tendency to decrease but the emissions level is still far above other region. The second region that release the most carbon dioxide is European Union and over the time is also leaning to decline. East Asia & Pacific, on the other hand even though on the lower level but demonstrate the trend to grow faster than the other region, even surpass above the world average. This indicates that although the CO2 level is still below the region of North America and European Union, but East Asia & Pacific display the potential to emit more CO2 as their economy keep developing. In addition, the region of Latin America & Caribbean and Sub Saharan Africa also appear to be increase in terms of carbon dioxide per capita although their emissions growth is not as fast as East Asia & Pacific. Middle East & North Africa region illustrate a similar manner of emission growth with East Asia & Pacific region but it can be noted that they are already emit more emission than East Asia & Pacific initially.

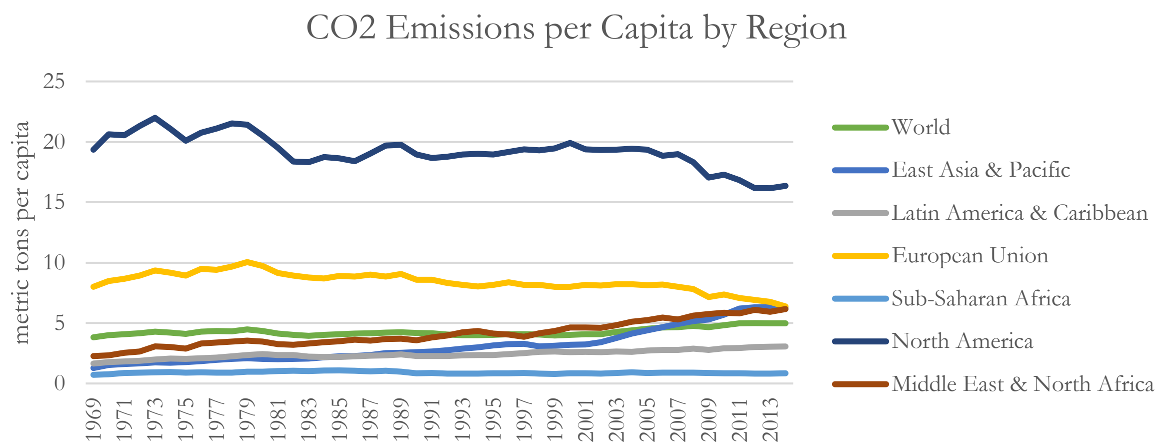


Figure 2. CO2 Emissions per Capita by Region
Source: World Development Indicators (2019)

Regarding the CO2 emissions per $ of GDP, we can grasp the impression of their growth trend in Figure 3. Figure 3 illustrate that the region of East Asia & Pacific emits the highest CO2 per $ of GDP among other region though indicate a tendency to decrease. North America until early 2000 was appeared to be in the same level with East Asia & Pacific but they decline much faster even until below the world average in 2014. In a contrast manner, Middle East region express the trend of increasing CO2 emissions per $ of GDP. Moreover, Sub Saharan Africa and European Union show a declining trend that are rather fast. Meanwhile Latin America & Caribbean appear to be only slightly decreasing over the time period.

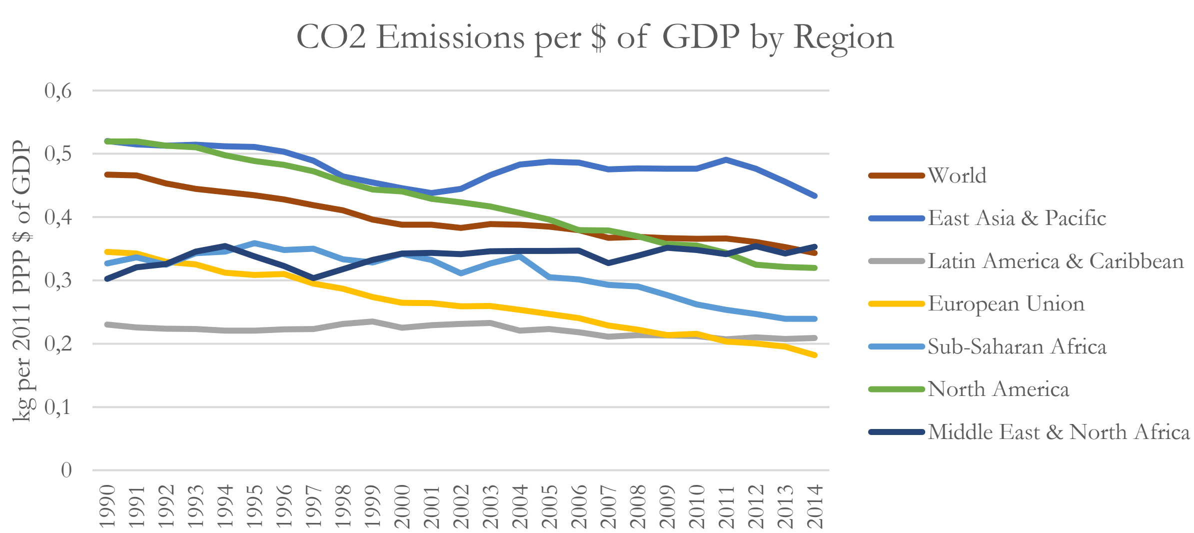


Figure 3. CO2 Emissions per $ of GDP by Region
Source: World Development Indicators (2019)

East-Asia and Pacific in Figure 4 have a lot of variability, consists of 38 countries including developed high income countries such as Australia, New Zealand, Japan, South Korea and also geographically small islands such as Palau, Samoa, and Nauru. However, it also includes ten member states of ASEAN. In figure 4, comparing ASEAN carbon dioxide emission to China, United States, and India shows that ASEAN is still below those economic giant countries. Nonetheless, it is interesting to study ASEAN region further since it also has an increasing trend in the past two decades though they are in the lower level compare to China and United States. In addition of Figure 2 of carbon dioxide per capita emissions by region, Figure 4 may indicate that China contributes as the majority as one of the highest emitters that cause East Asia & Pacific increase significantly compare to another region.

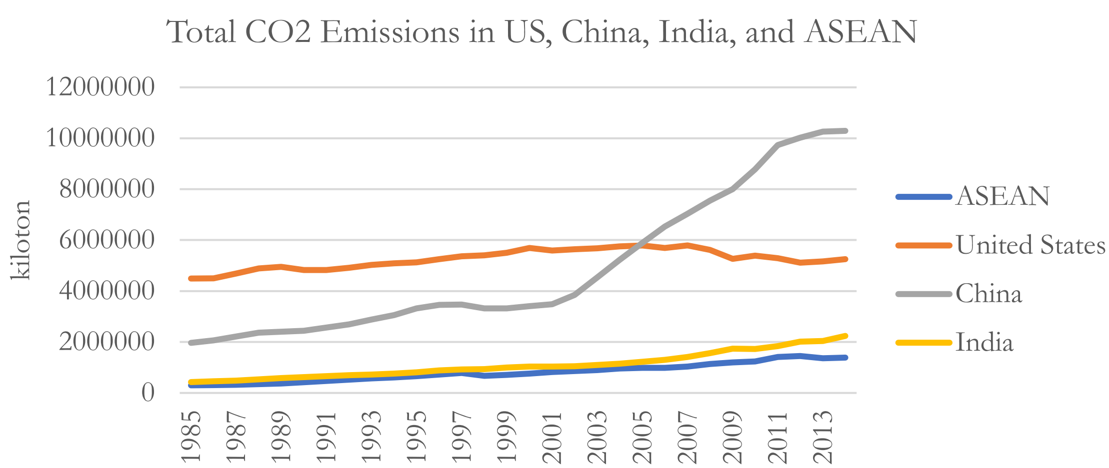


Figure 4. Total CO2 Emissions (kiloton) in US, China, India, and ASEAN
Source: World Development Indicators (2019)

Based on Figure 5, most of the countries are having an ascending trend on the carbon dioxide emissions (in metric tons per capita) that is used as an indicator for pollution with while Brunei and Singapore look very volatile compare to other countries. Malaysia is appeared to increase identical with Thailand and Indonesia. Vietnam, Philippine, Myanmar, and Lao also express a tendency of slightly inclining in emitting the CO2. In this figure, it is noteworthy to see that both Brunei and Singapore are a tiny nation in term of geographical compare to another ASEAN member but they emit the most CO2 in the region.

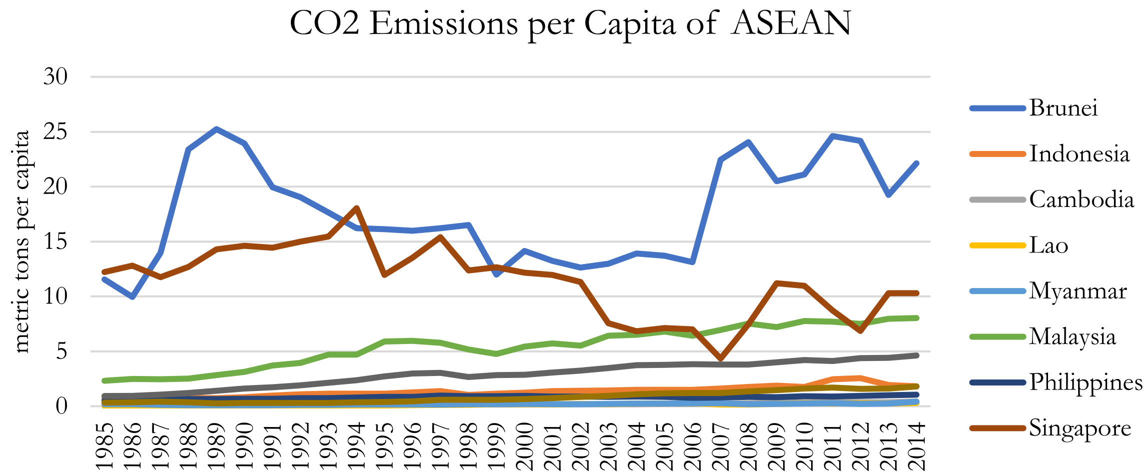


Figure 5. CO2 Emission (metric tons per capita) in ASEAN countries.
Source: World Development Indicators (2019).

The total GDP growth in Figure 6 also shows the similar trend of growing and declining at the same time in 1998 Asian Crisis and in 2008 Subprime Mortgage Crisis. Indonesia appears to have the biggest economy size followed by Thailand and Malaysia. Singapore comes in the fourth place but in terms of GDP per capita, Singapore is the highest. Philippine, Vietnam and Myanmar present increasing trend as well. Cambodia and Lao have similarity of growing only slightly. The increasing of CO2 emission trend seems to be in parallel with the increasing GDP growth trend in all the ASEAN countries. This makes it more important to public policy as one of the SDG goals is that of integration of climate change indicators into policy action, implementation and planning to ensure environmental sustainability.

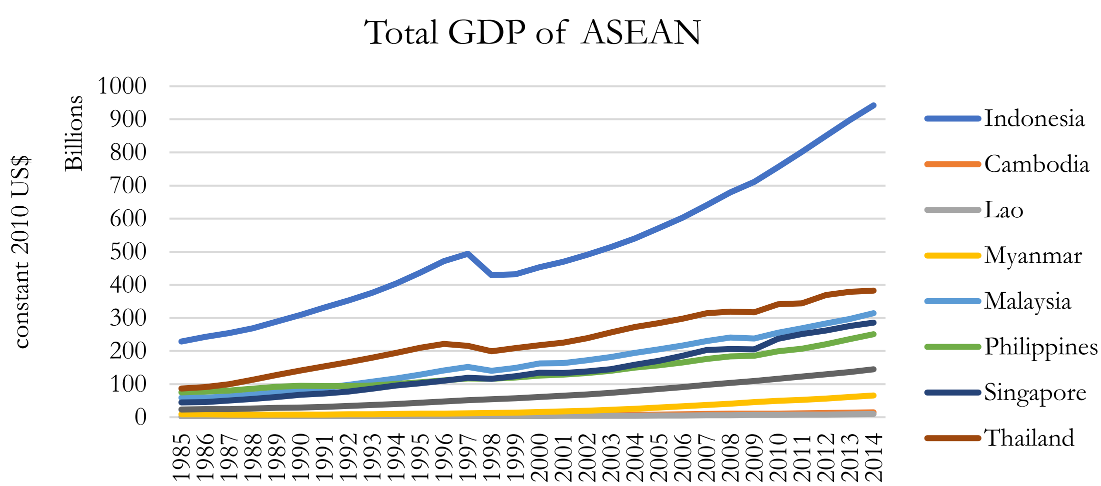


Figure 6. Total GDP (constant 2010 US$) in ASEAN.
Source: World Development Indicators (2019).

The notable economic growth of ASEAN as shown in the Figure 6 is mostly originated to growth of manufactures and industries. Nevertheless, industrial-based or manufacture economic growth may inevitably lead to environmental degradation. Researchers have put interests on the impact of economic growth to the environment because there is attention on the environment sustainability in the public policy agenda to make way in achieving the Sustainable Development Goals. Numerous studies have examined the relationship between environmental quality and economic growth by many authors and a lot of the empirical studies outcomes have been developed on the environmental Kuznets curve hypothesis. An inverted U shape curve of relation is presented by the hypothesis, explaining relation between environmental degradation and economic growth. It is interesting to see, whether the Environment Kuznets Curve is evident in ASEAN or not? What is the variable that has influence on the environmental degradation? This study specifically will focus on the analysis of environmental Kuznets curve relationships for CO2 emissions in ASEAN countries.

1.2. Objectives and Hypotheses

The objectives of the research are:

1. To determine whether there is an association between income measured by GDP and environmental degradation measured by CO2 emissions as shown by the environmental Kuznets curve for ASEAN countries.
2. To determine whether the energy consumption, GDP, and FDI has significant impact to the increasing level of CO2.

The research hypotheses are as follow:

H1. There is a relation between economic growth and carbon dioxide in ASEAN and there is a presence of the environmental Kuznets curve.

H2. Gross Domestic Products, energy consumption, institutional quality, and foreign direct investments have significant influence to the increasing level of carbon dioxide in ASEAN.

1.3. Writing Systematics

The writing systematics in this study is divided into five parts, as follows:

Part 1 is Introduction; consists of Background of the Study, Objective and Hypotheses, and Writing Systematics, Methodology and Time Frame, Feasibility, and Quality Indicators. This section discusses about the reason and surrounding circumstances why the study on this particular part is appealing.

Part 2 is Theoretical Frameworks; in general, it consists of The ASEAN Context, Environmental Kuznets Curve, and Review of Empirical Literature. This segment explains the regional organization of ASEAN, the theory of Environmental Kuznets curve and the alternate theories, and the review of empirical literature which examine about the findings of previous studies using various methods in Asia and also other part of the world.

Part 3 is Data and Methodology; consists of Data Sources and Model Specification, Panel Data Analysis, and Granger Causality Analysis. In this part we examine the data and methodology that is utilized in this paper.

Part 4 is Results. Part 4 is the result of the data processing and analyzing using the software Stata.

Part 5 is the Conclusions and Discussions; consists of conclusions of the whole paper and discussion about the results. This part also including the limitation of the study.

References is the descriptions of scientific journals, media sources that used in the thesis.

Appendices consist of graphs and the estimation results.

1.4. Methodology and Time Frame

1.4.1. Data Collection

Data are collected from secondary data sources done by desk study. One of the advantages of using secondary data is time saving. The researcher can use the data that is already collected by other people or in this case the data are from credible organizations. Another benefit that we can get is the assurance of the validity of the data. As the data are assembled by credible organizations, we can be certain that the data is reliable. Using secondary data is also cost efficient since the researcher was able to gather data in ASEAN countries which might not be feasible if the user of the data has to gather primary data by herself. However, data from secondary sources also have some drawbacks. Firstly, the data might not be up to date because it is not in control of the data user. Secondly, there might also be inaccuracy on the data. The last is, most of the secondary sources mostly provide aggregate or macro data and it limits the data user to get more detailed research.

Variables that are determined influenced the data collecting process which based on the model specification that was analyzed from existing literatures and researches. Data collected are consist of various measure for each variable and they are collected more than needed which we based on model specifications so that in analysis it is easier to determine a better model by adding or omitting variables and measures from the database that has been collected previously.

1.4.2. Data Analysis

Once the data were collected, the analysis will be done using the most recent Stata application. Since the model specification and analysis were done simultaneously, the variables or the observations are object to change. To determine the variables in the model, theoretical relevance must be taken into account, including the number of the observations. This is the reason why initially the research was aiming to observed environmental Kuznets curve in 4 countries (Indonesia, Malaysia, Philippines, Thailand) but then later added all the ASEAN member states (Brunei, Indonesia, Cambodia, Myanmar, Malaysia, Philippines, Singapore, Thailand, Lao, and Vietnam) for better variability of the data.

1.4.3. Time Frame

The whole research was done in approximately four months. The research design and the theoretical framework including literature review were done in the first two months and afterwards simultaneously the model specification followed. Data collection was done in one month while at the same time adjusting with model specification. The analysis and conclusion were done in approximately twenty days.

1.5. Feasibility

The research was expected to be completed in four months between data collection, analysis, and writing which was enough to deliver maximum results with the available resources and access in the university. Using secondary sources was also made possible to do the research for ASEAN region. Regarding the methodology, it is feasible to do despite some unavailability of the data in some countries which were omitted when regressing the estimations.

1.6. Quality Indicators

The sources of the data will be collected based on credible institutions or organizations. The most recent Stata application was also used which was available in the computer laboratory in the university. In addition, complementary viewpoints of experts and professional colleagues will guarantee a higher level of the research objectivity.

2. Theoretical Framework

2.1. The Association of Southeast Asian Nations

ASEAN, namely ten countries of Brunei, Myanmar, Cambodia, Lao, Malaysia, Indonesia, Singapore, the Philippines, Vietnam, and Thailand have progressed economically well. In comparison between ASEAN member, Singapore and Brunei are categorized into High Income Economies with GNI per capita $12,056 or more, according to World Bank, 2019. Malaysia and Thailand are into Upper-Middle-Income Economies ($3,896 to $12,055), and the rest of the member which are Cambodia, Vietnam, Myanmar, Philippines, Indonesia, Laos are in the Lower-Middle-Income Economies ($996 to $3,895). In term of economic growth, income in term of GDP as emerging Asia is projected to grow by an average of 6.1% annually in 2019-2023, based on the OECD Development Centre's Medium Term Projection Framework (MPF-2019) (OECD, 2019). Moreover, the report also mentioned that although the tendency of economic development is different in every country, the estimation is remained robust. On the other side, ASEAN is projected to demand energy by average of 4% annually which is greater than the world average namely 1.8% from 2005 to 2030 (International Energy Agency, 2009). In the "Fourth ASEAN State of the Environment Report" in 2009, policy makers find that more use in oil produced by fossil is a problem in administering the issue of climate change. The report also stated that an annual 5.1% increase of pollution in ASEAN is estimated to happen as an aftermath of primary energy use (ASEAN, 2009).

Even though to China, the United States, and India the CO2 emission is approximately small comparatively to per capita measure, policy makers appear to have concern on the continuing increase of CO2 emission from the use of fossil oil and on issues of climate change. In the past, during 1995 and 2004, average increase of 5.6% annually on CO2 had took place (ASEAN, 2009). However, in order to participate in Millennium Development Goals, ASEAN charter and ASEAN Community in the period of 2009-2015 has attempted to achieve the goals by creating plans and road map. Now, to reach sustainable development goals, ASEAN cooperation on environment is currently guided by the "ASEAN Socio-Cultural Community (ASCC) Blueprint 2025". ASEAN has cooperated closely in promoting environmental cooperation since 1977. Nevertheless, due to the differences on the economy condition of a few member states, it concerns the policy makers regarding the public policy and regional cooperation, whether the Kuznets effect will happen as they reach the threshold as a group undo the negative impact from economy growth on environmental. In terms of public policy, the increasing of GDP per capita may also be the priority instead of contributing to environmental sustainability.

2.1.1. ASEAN Environmental Conditions

The ASEAN region has a lot of natural resources that has been sustaining for Asia and the world. The resources support human activities including economic and social while providing water, fresh air, food, and energy. The region is faced by pollution along with environmental degradation because of the increasing population, economic growth, with the social inequality among and within the countries. These issues also lead to natural resources consumption and waste production which result to unsustainable development. Thus, although having an abundance of natural resources, ASEAN is confronted with challenges to keep the economic development and having less environmental degradation that comes with it. Forest in the ASEAN region cover "211,172,000 ha" in 2012, and in 2014 the protected area is 432,563,000 ha that takes 14% of the total land area (ASEAN, 2019, para 1). Majority of world's tropical peatlands[2] as much as 60% is located in Southeast Asia and it is also a host of 42% of the world's mangrove forests. ASEAN region which is located in the tropical area is endowed with abundant resources of freshwater (ASEAN, 2019, para 1). Data by ASEAN also shows that the region has "internal renewable water resources of 4,986 billion cubic meters" in 2014 with the highest per capita water resource availability owned by Brunei, Lao, and Myanmar (ASEAN, 2019, para 2).

The explanation on ASEAN's regional climate was put nicely in a summary on "The Fifth ASEAN State of Environment Report" (2017, p.17). El Niño and La Niña phenomena affect ASEAN region because the climate is "influenced by maritime wind systems, which originate in both the South China Sea and the Indian Ocean" (ASEAN, 2017, p.17). El Niño and La Niña change "the seasonal monsoon cycle and causes wide-ranging changes in weather patterns" (ASEAN, 2017, p.17). Moreover, the ASEAN region is prone to numerous natural disasters including "earthquakes and tsunamis, volcanic eruptions and typhoons" due to its unique geographical positioning on "the convergent boundaries of the Earth's tectonic plates and on the typhoon belt" (ASEAN, 2017, p.17). The ASEAN region also have "periodic and seasonal episodes of both floods and droughts" natural hazards that are often

[2] According to IUCN: "Peatlands are a type of wetlands that occur in almost every country on Earth, currently covering 3% of the global land surface. The term 'peatland' refers to the peat soil and the wetland habitat growing on its surface."

to happen are "floods, tropical storms and landslides" (ASEAN, 2017, p.17) "intense smoke haze and air pollution" that is affect by "the monsoon wind patterns" that happen in the summer. Over the past 50 years there has been an increase in the frequency and severity of both hydro-climatic and meteorological disasters. These disasters at least in part can be attributed to the changing natural environment and fast pacing effects of climate change (ASEAN, 2017, p.17).

Although only holds land surface of "3% in the world", Southeast Asia is well known for its diverse biological or natural heritage (ASEAN, 2019, para. 3). Three mega biodiversity countries (from total of 17 in the world) namely Indonesia, Malaysia and the Philippines are located in the Southeast Asia (ASEAN, 2019, para. 3). Data by ASEAN also stated that the majority of "biological diversity by 80%" acquired by these three countries altogether (ASEAN, 2019, para. 3). Approximately "9% of endemic bird and 11% of mammal species" are belonging to Southeast Asia region, which is the highest concentration of species in South East Asia, in comparison to similar tropical regions across South America and Sub-Saharan Africa (ASEAN, 2019, para. 4). Moreover, this area is home to "25 percent endemic vascular plant species" and only in the past two decades approximately 2000 species have been identified in the region (ASEAN, 2019, para. 4). Coral Triangle which is the world's center for marine biodiversity is located in in Southeast Asia, proved that the area is rich for marine biodiversity which further shows that the sea in the ASEAN region has the most diverse and large coral reefs compare to other region in the world where it possess more than "28% of the coral reefs" in the world (ASEAN, 2019, para. 5).

2.1.2. ASEAN Environmental Law

The environmental issues in the ASEAN Community and the region of Southeast Asia as a whole are ubiquitous. Besides causing tremendous damage to the environment, there is noticeable impact on regional security and sustainable development in Southeast Asia. Member States of ASEAN have seen rapid economic growth recently. However, at the expense of environment and sustainability, governments prioritize economic growth (Acharya, 1998). Environmental stress originating from climate change, excess urban area, water scarcity, deforestation, overfishing, and pollution is now negatively influenced Southeast Asia. Generally, four main actors of politics act in the Southeast Asia region which are: country as nation state, ASEAN as regional organization, international organization, and local environmental groups.

According to Srivithaya (2016), there are four perspectives of ASEAN integrated mechanism of law enforcement for good practices on environmental sustainability: administrative enforcement, civil enforcement and criminal enforcement, regional and sub-regional enforcement. To put effort in tackling the global environmental issues, ASEAN member states are cooperating in activities such as sharing of knowledge, best practices, and experiences, doing capacity building, carry out to put action to Multilateral Environmental Agreements (MEA). The ASEAN Working Group Multilateral Environmental Agreements (AWGMEA) put these activities inside their scope of area. The guidance of AWGMEA's activities are led by the ASEAN Socio-Cultural Community (ASCC) Blueprint in the ASEAN Roadmap to ASEAN Community, 2009 – 2015 (ASEAN Secretariat, 2009) in which the deepening of the regional cooperation is committed to improve national and regional capability to engage in the issues and commitments under the relevant Multilateral Environmental Agreements. Moreover, the promotion of the MEAs implementation has to be participated by each member country in ASEAN to handle measures related to atmosphere for instance climate change, ozone-depleting substances, and chemical waste (ASEAN Declaration on Environmental Sustainability, 2012). The mechanism for environmental law enforcement for all ASEAN member states to accomplish the roadmap will be divided into three categories: administrative law enforcement, civil law enforcement, and criminal law enforcement. The categories give environmental law enforcement three different point of view. In addition, enhancement of the mechanism of enforcement on environmental laws is supported by regional and sub-regional level of connection in ASEAN.

The scope of administrative law enforcement shall be a set of actions carried out by regulatory institutions to ensure compliance with the requirements of environmental regulations. Administrative powers may include certain types of sanctions, as well as actions that are non-judicial measures. Administrative enforcement actions derive their power directly from the laws for good environmental sustainability practices of ASEAN (Asian Environmental Compliance and Enforcement Network (AECEN), 2015), hence: 1) Issuance of permits or consideration of Environmental Impact Assessment (EIA) reports of all commercial and industrial transactions; 2) Punishment decisions shall be made by of co-bearers with administrative powers. A range of non-judicial and judicial measures might be ensured compliance with environmental law, such as monetary sanctions, suspension/cancellation of permits, EIA approval measures, etc.; 3) Administrative enforcement for preventive measures shall be included rewards or incentives for Corporate Social Responsibility (CSR) for environmental governance.

Civil law enforcement scope in ASEAN members is a set of actions that can assist governmental and non-governmental stakeholders and individuals to use civil or alternative remedies to ensure compliance with environmental law. Different ways shall be ensured to involve non-governmental actors and civil society with environmental expertise that can complement the State authorities "legal actions and sanctions to bring environmental wrongdoers into compliance with ASEAN members" environmental legislation (Srivithaya, 2016, p.3). Civil enforcement measures can provide important administrative and criminal enforcement support mechanisms to empower civil society action in general public awareness of environmental sustainability engagement (UNEP, 2007 as cited in Srivithaya, 2016). The Alternative Dispute Resolution (ADR) according to Srivithaya, (2016) can be used to support criminal prosecution–and may be more effective when it comes to civil litigation, particularly as costs may be reduced and ongoing relationships may not be damaged.

In order for environmental prosecutions to be effective, it is essential to have clear, robust, streamlined and easily understandable requirements for their procedural mechanism. Different criminal law enforcement deterrent and punitive measures can be enhanced by appropriate public awareness and engagement (UNEP, 2007 as cited in Srivithaya, 2016). At the same time, advertising and public awareness can increase the punitive effects of a conviction in environmental criminal cases. Standard penalties and penalties for criminal convictions may include terms of imprisonment, orders for community service, orders for rehabilitation or remediation, and withdrawal of licenses or permits. Polluting companies have treated them in many ASEAN members as "cost of wrong doing business." The ASEAN Socio-Cultural Community (ASCC) will play a major role in the establishment and implementation of an effective mechanism for enforcement of national administrative, civil and criminal laws in all ASEAN members integrated with regional and sub-regional enforcement of ASEAN environmental agreements. Srivithaya (2016) on the paper mentioned that eight ASEAN environmental agreements should be implemented in the national legislation of all ASEAN members as a source of good practices for environmental sustainability and sustainable development, thus: 1) The 2002 ASEAN Agreement on Trans-boundary Haze Pollution; 2) 1985 ASEAN Agreement in Conservation of Nature and Natural Resources; 3) 2005 Agreement on the Establishment of ASEAN Center for Biodiversity; 4) The 2011 Agreement between the Governments of the Members States of ASEAN and the Republic of Korea on Forest Cooperation; 5) The 2007 ASEAN Statement on Strengthening Forest Law Enforcement and Governance (FLEG); 6) The 1983 ASEAN Ministerial

Understanding on Fisheries Cooperation; 7) The 1997 MOU on ASEAN Sea Turtle Conservation and Protection; 8) 2004 ASEAN Protocol on Enhanced ASEAN Dispute Settlement Mechanism.

Srivithaya (2016) found that ASEAN countries have long experienced weak enforcement of their national environmental laws and regulations, ineffectively dissuading violations. It is therefore necessary to establish an integrated mechanism for regional and sub-regional enforcement of environmental laws relating to sustainable development. Srivithaya's research recommendation therefore as follows: 1) With the purpose of imposing 8 ASEAN environmental agreements under the structure of integrated work in ASEAN environmental law enforcement for sustainable development that should be supported by ASEAN Socio-Cultural Community (ASCC), all ASEAN members should cooperate to establish regulation and law and take on best practices on environmental sustainability. 2) To establish ASEAN Regional Networks of Environmental Law Enforcement for Sustainable Development (ARENELESD), which focus on the prevention and resolution of trans-boundary pollution in ASEAN Community region and the promotion of good practice on enforcement of environmental laws and ASEAN environmental agreements in all ASEAN members.

All ASEAN members therefore had the obligation to enact their national laws not only to implement the aforementioned eight regional environmental agreements, but also to implement multilateral international environmental agreements: the Vienna Convention, the Montreal Protocol, the UNFCCC, the Kyoto Protocol, the Stockholm Convention, the Cartagena Protocol, the Basel Convention, the Ramsar Convention, the Paris Agreement and the Rotterdam Convention. States enter into regional and international agreements in accordance with international law, under which they agree to enforce certain obligations within their own national legal systems. Consequently, ASEAN Member States are the main drivers for the implementation of international environmental rules because, if they are to have any chance of being effective, international agreements must be incorporated into national legal systems.

ASEAN announced the "ASEAN Joint Statement on Climate Change to the 15th Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC)" and the "5th Session of the Conference of Parties serving as the Meeting of Parties to the Kyoto Protocol" to show their commitment to deal with climate change. On the joint statement, they mentioned that they are "Further reaffirming that the UNFCCC and its Kyoto Protocol continue to be the basic framework and legal instrument for the international community to combat global climate change … Commit to continue actively contributing towards a successful outcome of the 15th session of the Conference of the Parties to the UNFCCC and the 5th session of the Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol." (ASEAN, 2012, p.1). This announcement shows further of that ASEAN commitment internationally.

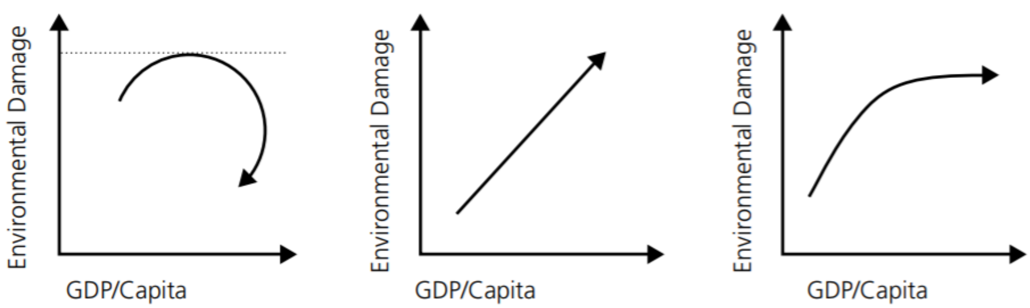
Regarding to ASEAN's commitment on Paris Agreement which they signed on 22 April 2016, ASEAN made a statement to reaffirm their commitment. In the statement, ASEAN declared that "Consider the Paris Agreement a historic achievement that reflects a delicate balance and allows each Party to forge its own strategic path, while at the same time promote international cooperation taking into account national interests, to contribute towards climate resilient development and global low greenhouse gas emissions. To this end, Parties will work together to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty in order to keep a global average temperature rise to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C above pre-industrial levels" (ASEAN-EU Statement on the Paris Agreement ,2017, p. 1). This reaffirmation expresses that ASEAN as a regional organization really committed to deal with the climate change.

2.2. Economic Growth and Environment

Different possible theories defining the relationship between economic growth and environmental degradation are exist. The limits theory believes that it is possible even before the economy arrive at the environmental Kuznets curve turning point, the environmental threshold can be passed. Arrow et al., (1996) as cited in Everett, Ishwaran, Ansaloni, & Rubin (2010), argue that the risk to make small alteration resulting to great harm indicates by only putting the center attention on economic growth to bring environmental results could be unproductive. For example, "in the context of biodiversity, increased spending on maintaining species diversity will not be able to recreate extinct species" (Dietz, 2000 as cited in Everett et al., 2010, p.19). The limits theory explains the relation between economy and environment as the economy decline as environmental degradation reaching a threshold beyond that production is so affected severely as shown in figure 5.a (Meadows, et al., 2004 as cited in Everett et al., 2010).

Another theory doubts that turning points are existing and regards as the economic inclining the environmental damage keeps inclining (see figure 5.b) (Stern (2004 as cited in Everett et al., 2010). This share a similar manner to "the new toxics notion" mentioned by Davidson (2000) as cited in Everett et al., (2010, p. 19), that as the economic keep growing the existing pollutants will decline but will be replaced by even more new pollutants increasing the level of pollution.

Stern (2004) as cited in Everett et al., (2010) argues in the scope of international competition to describe relation between economic growth and environment condition. The race to the bottom theory explains that at the beginning international competition results in worsening the environment condition until the point where rich countries begin to reduce their negative impact on the environment but instead moving their production activities to poorer countries thus moving out the pollution. A situation that is not improve (see figure 5.c) is the best case condition or also called the net effect.



a) Limits Theory b) New Toxics and Davidson c) Race to the Bottom

Figure 7. Alternative Perspective of the Economic Growth and Environmental Degradation Relationship
Source: Everett et al., (2010)

2.3. Environmental Kuznets Curve

The rationale behind the Environmental Kuznets curve hypothesis has been put in brief by Panayotou, (1993) as follows: "At low levels of development both the quantity and intensity of environmental degradation is limited to the impacts of subsistence economic activity on the resource base and to limited quantities of biodegradable wastes. As economic development accelerates with the intensification of agriculture and other resource extraction and the takeoff of industrialization, the rates of resource depletion begin to exceed the rates of resource regeneration, and waste generation increases in quantity and toxicity. At higher levels of development, structural change towards information-intensive industries and services, coupled with increased environmental regulations, better technology and higher environmental expenditures, result in levelling off and gradual decline of environmental degradation." Panayotou (1993, p. 2).

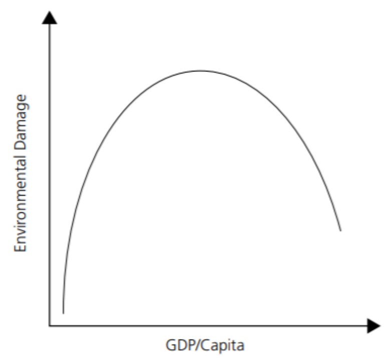


Figure 8. Environmental Kuznets Curve
Source: Everett et al., (2010)

According to Stern, Common, & Barbier (1996), this argument also leads to a hypothesized relationship that takes the form of an inverted U (see Figure 6) between environmental degradation and per capita income. Such a relationship is sometimes referred to as an "environmental Kuznets curve," after Kuznets (1955), who's theory assume that a measure of inequality of income distribution and income level construct an inverted U shape. Nevertheless, Stern, Common, & Barbier (1996) also consider that the theory has limitation on the empirical application of the concept, they believe that the utilization of environmental Kuznets curve theory is restricted to the descriptive statistic.

Senisterra (2017) in his study claims that one of the main criticisms of the environmental Kuznets curve theory strikes at the heart of the model itself in that it takes income as the independent variable and environmental degradation as the dependent one. According to Arrow et al. (1995) and Stern (2004) as cited in Senisterra (2017), the model assumes that "environmental damage does not reduce economic activity sufficiently to stop the growth process and that any irreversibility is not so severe that it reduces the level of income in the future" (Stern, 2004 as cited in Senisterra, 2017, p.10). Putting it differently, income is taken as having an external cause and it is expected that environmental degradation does not influence economic production (Senisterra, 2017). In brief, the environmental Kuznets curve model assumes that the economy will be sustainable over time. However, if environmental damages overpower the productivity of an economy, then continuous growth in the early stages of development may "turn out to be uneconomic" (Senisterra, 2017, p.11).

Another perspective, in its analysis and conclusions of World Bank (1992) in the 1992 World Development Report was careful, did not claim that economic growth alone is the solution to all environmental problems, and stressed the importance of environmental protection policies. In interpreting the policy implications of their empirical results, many of the other contributions to the environmental Kuznets curve literature are equally cautious. Before attempting to draw far-reaching political conclusions, it is necessary to be clear about the empirical status and implications of the environmental Kuznets curve hypothesis.

2.4. Review of Empirical Literature

Many studies have examined the relations of economic growth and environment, specifically but not limited to economic growth, energy consumption, institutional quality, foreign direct investment, and environmental degradation. These studies show mixed evidence on the relationship and the existence of environmental Kuznets curve hypothesis.

Various indicators have been used to represent both economic growth and environment condition. For instance, Grossman & Krueger (1995) look into the narrow form of relation between various environmental measures and per capita income. Grossman's study includes four types of indicators: pollution contains in urban air, the condition of the oxygen in the river channel, river contaminations that indicate the presence of feces, and heavy metal pollution in the river channel. His research finds no prove that the environmental condition worsens with the increasing in the economy. Nonetheless, for most indicators to some degree, economic growth at the beginning stage results in deterioration but then followed by a phase of improving recovery. This section discusses about empirical findings from previous researchers on the specific topic of economic and environment as well as other variable of interests.

2.4.1. Higher Income Leads to Less Carbon Dioxide Emissions and the Environmental Kuznets Curve is Evident

Many studies attempt to prove the existence of environmental Kuznets curve (e.g. Halicioglu (2009), Jalil & Mahmud (2009), Aruga (2019), Apergis(2006), Linh & Lin (2014), Farhani, Shahbaz, & Arouri (2013)). Jalil & Mahmud (2009) study works towards at questioning if carbon dioxide and national income have Environmental Kuznets curve relationship in the long run in China by making use of ARDL estimations. They found that a quadratic relationship holds in environmental Kuznets curve relationship in China between income and carbon dioxide emission during the period of 1975-2005. Aruga (2019) analyses the observation in 19 Asia-Pacific countries by energy-environmental Kuznets curve (EEKC) proposition. His study shows mixed evidence between the whole sample, low income group, middle income group, and high income group. The whole sample and low-income models are cointegrated, while they do not holds so in the middle income countries group, and the high-income group are weakly cointegrated, therefore mixed results of the enviornmental Kuznets Curve Hypothesis. Study by Halicioglu (2009) using ARDL cointegration in the country of observation Turkey provides some support that real income per capita is statistically significant with positive sign and squared real income per capita has negative sign to dependent variable of CO2 emissions. However, the graph of CO2 and real income per capita does not support the existence of environmental Kuznets curve in Turkey.

Study by Farhani, Shahbaz, & Arouri (2013) examine the connections between national income and carbon dioxide emissions using the environmental function for 11 Middle East and North African (MENA) countries over the period 1980-2009. The outcomes prove that the environmental Kuznets curve exist by making use of cointegrated tests and causal relationship. Apergis (2006) found mixed results utilizing data on CO2 emissions per capita and real GDP per capita on the observed fifteen developed countries in the period of 1960–2013. Apergis' study making use cointegration approach on both of the panel data and time series data. In his explanation, the mixed evidence might arise as a result of time dependence of cointegrating coefficients. His results show the existence of environmental Kuznets curve hypothesis in 12 out of the 15 countries.

2.4.2. Energy Consumptions Increases Carbon Dioxide Emissions

Jalil & Mahmud (2009) analyze whether energy consumption has influence in the long period of time to carbon emissions among other variables China as the observed country by applying Auto regressive distributed lag (ARDL) into their model. What is more, Granger causality is also utilized with the outcome of one-way causality of economic growth to CO2 emissions. In the long run, the main factors that influence carbon emission are not only income but also carbon emissions. Also, positive coefficient is shown on trade variable but statistically not influencing the CO2 emissions. Additionally, Niu, Ding, Niu, Li, & Luo(2011) who study the causality from energy consumption to CO2 emissions found that the causality was observed in general with the existence of opposite relationship too. Panel data model in Niu et al., (2011)'s study demonstrates that there are massive differences between developed and developing countries in the variable of interest of unit energy consumption, the efficiencies of energy use, carbon emissions, and carbon emissions of unit GDP. Research in Turkey for the period of 1960 - 2003 (Halicioglu, 2009) has empirical findings that energy consumption is influencing carbon emissions with variable income become the most significant variable.

2.4.3. Better Quality of Institutions Reduce Carbon Dioxide Emissions

Ibrahim, M. H. & Law, S. H. (2015) investigate 40 Sub-Sahara African countries by making use of the system generalised method of moments (GMM). They study in a panel analysis the correlations in explaining carbon dioxide emissions in regard to the roles of trade and institutional quality. Ibrahim, M. H. & Law, S. H. (2015) discover that institutional reforms are unambiguously improving environmental conditions. In addition, they mentioned that trade impacts on the environment have a tendency to be determined by the institutional setting of a country and trade openness has detrimental effect on the environment in countries that have low institutional quality and advantageous to countries that have high institutional quality. Mentioned in Bhattacharya, Churchill, & Paramati (2017) study, democratic government that has the nature of more open and responsive is possible to function better than in comparison autocratic government in implementing environmental policies (Bernauer & Koubi, 2009 as cited in Bhattacharya et al., 2017), although others have been more skeptical of this claim (Shearman & Smith, 2007; Ward, 2008 as cited in Bhattacharya et al., 2017). Furthermore, better institutional positioning and better quality institutions give the means to the governments to internalize externalities attributable to pollution. Better condition of the government and more stable political situations are also able to execute appropriate tax rates, subsidies and related policies in the energy sector to reduce unwanted emissions (Bhattacharya et al., 2017).

Study by Carlsson & Lundström (n.d.) find that emissions decrease in better institutions in countries that has less industry share in their national income while emissions increase in countries that has better institutions with more share of industry in their GDP. Thay also find that "The effect of political freedom on CO2 emissions is insignificant, most probably since CO2 emissions is a global environmental problem and hence subject to free-riding by the individual countries." (Carlsson & Lundström, n.d., p.81). The results by Chang & Chang (2010) the influence of corruption is insignificant in both high corruption and low corruption countries.

2.4.4. Foreign Direct Investment Increases Carbon Dioxide Emissions

Concerning on foreign direct investment (FDI) as a measure which affects environmental degradation is focused on various studies. Ridzuan, Noor, & Ahmed (2014) analyses pollution-haven hypothesis model regarding the impact of FDI on carbon dioxide emissions for original ASEAN5 from the time period of 1970-2008. They found mixed evidence between the five countries. The results of ECM-ARDL for short run analysis display mixed evidence between the dependent and independent variables namely CO2, GNI, manufacturing value added as percentage of GDP, and FDI inflow. Besides the results of the long run elasticities exhibit that in Indonesia and Thailand for GNI, manufacturing, and FDI are significantly and positively influenced the level of CO2. As contrast to Philippines, the variable that is positively impact the level of CO2 in this country is only FDI inflow.

Atici (2012) study the interaction in the group of ASEAN countries between the variables of trade, FDI, and the environment in terms of carbon emissions. The findings appear that CO2 emissions show "an inverted-S shape" in the ASEAN region. For the most part, exports as a percentage of the gross domestic product (GDP) are main features to carbon emissions in the developed, developing and late-developing ASEAN countries. Nonetheless, the study found no support for the Foreign Direct Investment's harmful impact on environmental condition.

Research by Linh & Lin (2014) found that in Vietnam more pollution is cause by FDI since less regulation on the environment attracted more investment thus more pollution. In this case it supports the pollution haven hypothesis which is "for given levels of environmental policy, polluting industries will relocate to countries with weaker environmental regulation" (Linh & Lin ,2014, p. 230).

Table 1. Summary of literature review and major findings

Authors	Variables	Methodology	Countries	EKC	Income Effects on CO2
Abdul Jalil and Syed F. Mahmud (2009)	CO2, GDP, Trade	Auto regressive distributed lag (ARDL)	China	Yes	Yes
Ferda Halicioglu (2009)	CO2, GDP, EC, Trade	Bounds testing, Granger causality	Turkey	No	Yes
Niu et al. (2011)	CO2, GDP, EC	Pedroni cointegration	Thailand	-	Yes
Atici (2012)	CO2, GDP, Export, FDI	Random and Fixed Effect (Panel)	Malaysia	-	Yes
Ridzuan et al. (2014)	CO2, GNI, Manufacturing, FDI	ARDL	Thailand Indonesia Philippines	-	Yes (3.51) Yes (0.95) Insignificant
Ibrahim, M. H., & Law, S. H (2015)	CO2, Institutional Quality, Trade	Generalized Method of Moments (GMM)	40 Sub-Sahara African countries	Yes	-
Farhani, Sahbi and Shahbaz, Muhammad and Arouri, Mohamed El Hedi (2013)	CO2, GDP, Trade, Urbanization	FMOLS & DOLS	Middle East and North African Countries	Yes	Yes
Aruga, Kentaka (2019)	Energy Use, GDP	FMOLS & DOLS	Asia Pacific Countries	Yes	Yes (Mixed Results)
Apergis, Nicholas (2006)	GDP, CO2	Common Correlated Effects (CCE), FMOLS, and quantile est.	15 Developed Countries	Mixed	Yes (Mixed Results)
Bhattacharya, Churchill, & Paramati (2017)	GDP, CO2, EC, Institutions	GMM	85 Countries	-	Yes (Mixed Results
Carlsson & Lundström (n.d.)	CO2, economic freedom, political freedom	Box-Cox Regression	75 Countries	-	-
Linh & Lin (2014)	CO2, GDP, FDI, EC	OLS, Granger Causality, VECM	Vietnam	Yes	Yes
Chang & Chang (2010)	CO2, Corruption	VAR (Vector Autoregressive)	62 Countries	-	-

3. Data and Methodology

3.1. Model Specification and Data

This study will employ a span of 29 years of annual time-series data from 1985−2014 period into consideration. The data is obtained from various sources, the CO2 data the economy data of GDP, FDI, and energy consumption are taken from the World Bank's development indicators databases (http://data.worldbank.org/) and the Quality of Government for institution variable. The main components are the CO2 emissions per capita in metric tons, GDP per capita in constant 2010 US$ will represents the economic growth indicator, and energy use per capita in kilograms of oil will be equivalent as energy consumption. The variables mentioned will be transformed into natural logarithmic forms. The estimation of econometric regression line is as follows:

$$\ln \mathrm{CO2}_t = \beta_0 + \beta_1 \, ln\, GDP_t + \beta_2 \, ln\, EC_t + \beta_3 \, ln\, INT_t + \beta_4 \, ln\, FDI_t + \varepsilon_t \quad (1)$$

$$\ln \mathrm{CO2}_t = \beta_0 + \beta_1 \, ln\, GDP_t + \beta_2 (ln\, GDP_t)^2 + \beta_3 \, ln\, EC_t + \beta_4 \, ln\, INT_t + \beta_5 \, ln\, FDI_t + \varepsilon_t \quad (2)$$

where c_t is CO2 emissions per capita, EC_t is energy use per capita, GDP_t is current GDP per capita, GDP_t^2 is square of constant GDP per capita (see Table 2), INT_t is representing institutional quality using Bayesian Corruption Index, FDI_t is foreign direct investment in percentage of GDP, and ε_t is the regression error term. The use L letter in front of the variable names show that variables are in the natural logarithmic form.

The equation (1) will be used to estimate the relationship of carbon dioxide with economic growth, energy consumption, institutional quality and foreign direct investment. In the equation (2), variable squared GDP per capita is added to see the evidence of the environmental Kuznets curve. The presence of the environmental Kuznets curve will be verified by β1 being significantly positive and β2 significantly negative. Based on equation (2), the turning point of income or in this case GDP per capita (in natural logarithm) can be estimated as $(-\beta_1/2*\beta_2)$.

Table 2. Variable Description

Name of variable	Description and measurement units	Source
Carbon Dioxide (CO2)	"Carbon dioxide emissions from the burning of fossil fuels and the manufacture of cement. It includes carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. Data are in metric tons per capita".	Carbon Dioxide Information Analysis Center (CDIAC)
Gross Domestic Products Per Capita (GDP)	"GDP from the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. Dollar figures for GDP are converted from domestic currencies using 2010 official exchange. Data are in constant 2010 US dollars per capita." Data converted from total to per capita using population figure from its corresponding country.	World Development Indicators
Energy Consumption (EC)	"Energy use refers to use of primary energy before transformation to other end-use fuels, which is	World Development Indicators

Name of variable	Description and measurement units	Source
	equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport. Data are in kilogram of oil equivalent per capita".	
Institutional quality (INT)	"The Bayesian Corruption Index is a composite index of the perceived overall level of corruption: with corruption referred to as the abuse of public power for private gain. The BCI index values lie between 0 and 100, with an increase in the index corresponding to a raise in the level of corruption".	The Quality of Government Institute (Dahlberg, et al., 2019)
Foreign Direct Investment (FDI)	"Foreign direct investment are the net inflows of investment to acquire a lasting management interest. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. Data are in the percentage of GDP".	World Development Indicators

Table 3 of summary statistics is used to explain the descriptive statistics of the dataset to gain some insight on the data condition and their attributes. Based on the descriptive statistics, Brunei contributes the most CO2 as Brunei has the highest average of 21.025 metric ton per capita of carbon dioxide among other countries followed by Singapore by 9.641 metric ton per capita. During the period of 1985 – 2019 of 29 years, Brunei has also the highest of average annual growth rate of carbon dioxide emissions by 29,3%. Unexpectedly in a similar manner, Cambodia has also high annual average growth rate of carbon dioxide by 22%. In terms of GDP per capita, the highest average holds by Singapore and then Malaysia and Brunei are in the second and third highest respectively.

Table 3. Summary Statistics by Country

	Mean	Max	Min	Std. Dev.	GR
Brunei					
CO2	21.025	67.189	3.258	16.754	.293
GDP	40046.41	66001.58	31430.96	7424.928	-.007
EC	6684.785	9829.333	1234.936	1841.453	.061
INT	30.17	32.924	25.402	1.956	-.004
FDI	2.404	4.541	-1.321	1.553	-.147
Cambodia					
CO2	.128	.438	.004	.11	.220
GDP	648.301	1137.224	321.36	255.24	.039
EC	308.888	416.94	251.336	56.053	.030
INT	58.405	59.94	57.046	.696	-.000
FDI	7.592	14.258	1.751	4.018	.150
Indonesia					
CO2	.928	2.56	.227	.599	.043
GDP	1810.141	4130.644	656.747	990.293	.032
EC	577.971	883.911	297.201	201.085	.026
INT	55.524	57.339	47.233	2.488	-.005
FDI	.991	2.916	-2.757	1.286	.117
Laos					
CO2	.122	.297	.038	.076	.066

	Mean	Max	Min	Std. Dev.	GR
GDP	819.074	1730.405	401.63	396.514	.044
EC	.	.	.	.	.
INT	50.904	51.351	46.999	1.06	-.004
FDI	3.628	9.49	-.068	2.763	.385
Malaysia					
CO2	4.259	8.033	1.352	2.285	.045
GDP	5139.329	11528.3	1353.846	3014.6	.039
EC	1609.236	2967.541	523.574	796.241	.042
INT	36.463	40.653	34.608	1.497	-.002
FDI	3.777	8.761	.057	1.73	1.695
Myanmar					
CO2	.174	.417	.101	.056	.033
GDP	410.2	1489.506	150.221	375.533	.042
EC	285.414	371.869	254.455	20.534	.006
INT	64.983	66.639	62.83	1.185	.001
FDI	3.334	6.985	1.819	1.575	.151
Philippines					
CO2	.736	1.055	.317	.177	.025
GDP	1627.978	2891.359	1059.335	416.55	.018
EC	455.862	512.748	406.507	25.279	.004
INT	61.014	64.361	55.226	2.224	-.001
FDI	1.174	3.207	-.327	.886	-.053
Singapore					
CO2	9.641	18.041	.349	4.588	.128
GDP	23545.84	55235.51	3389.556	16265.69	.051
EC	3838.243	7370.653	1292.241	1636.903	.040
INT	12.927	17.29	9.86	2.28	-.012
FDI	12.621	26.521	3.646	6.622	.143
Thailand					
CO2	1.817	4.622	.136	1.465	.071
GDP	2647.132	6126.244	570.857	1734.102	.043
EC	957.868	1991.636	360.578	522.855	.041
INT	47.742	52.779	46.213	2.002	.002
FDI	2.051	6.435	.202	1.5	.255
Vietnam					
CO2	.633	1.804	.229	.446	.048
GDP	892.667	1834.652	376.619	450.279	.049
EC	359.053	665.878	250.622	133.848	.019
INT	55.051	55.86	53.216	.607	-.001
FDI	5.045	11.939	-.001	3.002	7.157

Notes: (1) CO2: Carbon Dioxide in metric tons per capita; (2) GDP: Gross Domestic Products in constant 2010 US$ per capita; (3) EC: Energy Consumption in kg of oil equivalent per capita; (4) INT: Institutional quality in Bayesian Corruption Indicator (the index values lie between 0 and 100, with an increase in the index corresponding to a raise in the level of corruption); (5) FDI: Foreign Direct Investment net inflows in percentage of GDP; (6) GR: Average annual growth rate from 1985-2014 in percentage.

Table 4 shows the summary statistics for ASEAN. Looking at standard deviation of variable CO2, it shows that variations may be volatile within a country because between and within standard deviation are not too much different, with 6.688 for between and 5.563 for within. For variable of GDP, we can see that there are big differences between country (13323.120 US$ per capita) but rather small differences within country (6136.851 US$ per capita). In a similar way, variable EC also indicates more variations between country compare to within country, as expected. For variable of INT, it displays variation in between with the index value of 16.922, with the minimum 12.927 and maximum 64.983 for between country of observation over time. It also shows relatively small differences of index value by 1.840 in within. Moreover, for variable of FDI we also expected the nature of volatility in the data. It is proven by the variations in between and within are almost equal if we compare them, by 3.522 and 3.120 of percentage of GDP respectively.

Table 4. Summary Statistics of ASEAN

Variable		Mean	Std.Dev.	Min	Max	Observations
CO2	overall	3.940	8.486	0.004	67.189	N =540
	between		6.688	0.122	21.025	n =10
	within		5.562	-13.827	50.104	T =54
GDP	overall	7993.660	13810.140	150.221	66001.580	N =485
	between		13323.120	410.200	40046.410	n =10
	within		6136.851	-1.22e+04	39683.330	T =48.500
EC	overall	1767.196	2294.305	250.622	9829.333	N =371
	between		2194.165	285.414	6684.785	n =9
	within		904.405	-3682.653	5299.606	T =41.222
INT	overall	45.762	16.528	9.860	66.639	N =282
	between		16.922	12.927	64.983	n =9
	within		1.840	37.471	50.799	T =31.333
FDI	overall	4.419	4.856	-2.757	26.521	N =348
	between		3.522	0.991	12.621	n =10
	within		3.120	-4.555	18.320	T = 34.800

Notes: Variable units are on Table 3.

3.2. Econometric Methodology

3.2.1. Stationarity Test

To investigate the degree of integration in the time series or panel data analysis because if the variables are non-stationary and/or non-cointegrated the regression results may be spurious, not what appears to be. The panel unit root test is put into use in the study that utilizes panel data analysis consistent with the literature that has suggested that a better control embedded in panel unit root tests and as compared to that for time series data (Baltagi, Bresson, & Pirotte, 2007).

They explain that the panel unit root tests examined the existence of cross-sections that is created from a single series, which the tests are plainly "the best of both worlds: the method of dealing with nonstationary data from the time series and the increased data and power from the cross-section" (Baltagi & Kao, 2000 as cited in Hurlin & Mignon, 2007, p.2) . Thus, Im, Pesaran and Shin (IPS)

(2003) and Fisher-type unit root test for panel data are used in this study. The general equation built by IPS (2003) as cited in Hurlin & Mignon, (2007) of the test can be specified as follows (model without individual effects and no time trend):

$$\Delta y_{i,t} = \alpha_i + \rho_i y_{i,t-1} + \sum_{z=1}^{\rho_i} \beta_{i,z} \Delta y_{i,t-z} + \varepsilon_{i,t} \tag{3}$$

IPS test enable for heterogeneity in the value of ρ_i under the alternative hypothesis. "The null hypothesis is expressed as H0 : $\rho_i = 0$ for all i = 1,….., N and the alternative hypothesis is H1 : $\rho_i < 0$ for i = 1,….., N1 and $\rho_i = 0$ for i = N1 + 1,…..,N, with 0 < N1 ≤ N. The alternative hypothesis allows to have unit roots for some but not all of the individual series" is stated Hurlin & Mignon, (2007, p.5) to describe the null and alternative hypothesis in the panel unit root tests.

3.2.2. Panel Cointegration Test

Once the stationarity tests utilize to discover the order of integration of the data, we employ the Pedroni, Kao, and Westerlund panel cointegration tests. These tests are used to perform residual-based cointegration tests (Aruga, 2019). Still the tests of Pedroni are more thorough as this test in the panel model enable heterogeneous coefficients while the Kao test does not examine such heterogeneities (Nasir, Huynh, & Tramb, 2019). The following model shows the cointegration test for panel data.

$$y_{it} = x'_{it}\beta_i + z_{it}\gamma_i + e_{it} \tag{4}$$

The test is subject on "the covariates in x_{it} are not co-integrated themselves" (Nasir et al., 2019, p. 134). β_i indicates the vector bringing "the co-integrating phenomenon", that may vary throughout panels and "γ_i is a vector with coefficients on z_{it}", which is recognized as "deterministic terms" to deal with effects that are panel specific and linear across time, e_{it} is error term, that should be "in line with white noise $e_{it} \sim N(0; \sigma^2)$" (Nasir et al., 2019, p. 134).

Pedroni (1999) as cited in Nasir et al., (2019) assesses that every "panel-specific co-integrating vector" from Equation (4) has various "individual slope coefficients" (p. 135). Then, the Pedroni (1999) test as cited in Nasir et al., (2019) uses the unit root test for residual estimation through the Augmented Dicky Fueller (ADF) regression. This approach allows for incorporating each ρ_i rather than the same ρ like Kao (1999) as cited in Nasir et al., (2019). Moreover, this approach is subsequent to the "convergence characteristics" after suitable standardization (p. 153). An alternate co-integration test is used by Westerlund (2005) as cited in Nasir et al., (2019), which believes that the particular "co-integrating vectors have different individual slope coefficients" (p. 135). This test allocated for cross sectional dependency and is mostly used to check for robustness. Moreover, Westerlund (2005) as cited in Nasir et al., (2019) is commonly used to handle the problem raised by specifying structural breaks endogenously.

3.2.3. Specification Tests for Panel Regression Model

For testing the environmental Kuznets curve hypothesis, this study uses two panel models i.e. the simple panel regression model and panel cointegration model. Before estimating with panel cointegration model, pooled-OLS, fixed-effects, and random-effects models were initially picked to estimate the panel regression model.

The pooled-OLS, fixed-effects, and random-effects models were initially picked to estimate the panel regression model. Then, we determined the statistically appropriate model among these three models by the following specification tests i.e. the Wald test for measuring if the fixed effect model was appropriate compared to the Pooled OLS Model, the "Breusch-Pagan Lagrange Multiplier (LM) tests" to choose between the random and pooled OLS method, the Hausman test was performed to identify the suitable model between the fixed-effects and random-effects models.

Concerning the fixed and random effects model, they are two widely known models utilized in modelling panel data. The fixed effects model portions of specifications are managed using orthogonal forecasts. Al-mulali, Weng-Wai, Sheau-Ting, & Mohammed (2014) mentioned in their study that the fixed effects model can remove the bias problems occurring from the omitted variables that do not change over time as important advantage of the model. Concurrently, their study stated that the model for random effect draws the inference across the equivalent effects of vectors from the cross section, and the effect between the cross section and time series not corelated. The study concluded that the random effects model undertakes that the effects with the residuals do not have any correlation.

Then to decide the suitable model, the Hausman test was applied to compare the random and fixed effects estimates of coefficients. Chi-square statistics is the foundation of the Hausman test; if the Chi-square statistic is significant, the random effects model is not valid, and the fixed effects model should be used (Al-mulali et al., 2014).

A fair amount of preceding studies suggests that the cointegration analysis necessarily should be done through two main models i.e. OLS based estimators such as FMOLS (Fully Modified OLS) and DOLS (Dynamics OLS). The well-known FMOLS and DOLS are used in this study as these methods allocated for heterogeneity and cross-sectional dependence in the cointegration vectors. Before employing the FMOLS and DOLS estimation the study employs the panel unit root and panel cointegration tests to check for cointegration between variables. However, if these tests prove that there is no cointegration between the variables both the FMOLS and DOLS models to equation cannot be applied.

The main and fundamental distinction among the FMOLS and DOLS approach is how to act correcting the autocorrelation in regression. According to Pedroni (1996, 2001) as cited in Nasir et al. (2019). Using Newey-West for correction is allowed by FMOLS while the DOLS estimator permits for adding up more lagged variables. Pedroni (1996, 2001) as cited in Nasir et al. (2019) recommends this approach for estimating the coefficients used for measuring the long-run effects (Equation (5)).

$$\hat{\beta}_{FMOLS}=\left(\sum_{i=1}^{N}\hat{L}_{22i}^{-1}\sum_{t=1}^{T}(x_{it}-\bar{x}_i)^2\right)^{-1}\sum_{i=1}^{N}\hat{L}_{11i}^{-1}\hat{L}_{22i}^{-1}\left(\sum_{t=1}^{T}(x_{it}-\bar{x}_i)y_{it}^{*}-T\hat{\delta}_i\right) \quad (5)$$

In which,

$$y_{it}^{*}=(y_{it}-\bar{y}_i)-\left(\frac{\hat{L}_{21i}}{\hat{L}_{22i}}\right)\Delta x_{it}+\left(\frac{\hat{L}_{21i}-\hat{L}_{22i}}{\hat{L}_{22i}}\right)\beta(x_{it}-\bar{x}_i) \quad (6)$$

Then, following equation shows the DOLS estimator.

$$y_{it}=\beta_i' x_{it}+\sum_{j=-q}^{q}\zeta_{ij}\,\Delta x_{i,t+j}+\gamma_{li'}D_{li}+\varepsilon_{it} \quad (7)$$

Study by (Kao & Chiang, n.d.) on their paper "On the estimation and inference of a cointegrated regression in panel data" which compare OLS, FMOLS, and DOLS found that "DOLS outperformed both the OLS and FMOLS estimators (p. 206). The FMOLS estimator is also complicated by the dependence of the correction in [corrections for endogeneity and serial correlation to the OLS estimator] upon the preliminary estimator (here [Kao & Chiang, n.d.] use OLS), which may be biased in finite samples. The DOLS differs from the FMOLS estimator in that the DOLS requires no initial estimation and no non-parametric correction." (p. 206). We apply both FMOLS and DOLS to the panel regression to analyze the long run relationships between dependent and independent variable and to examine the existence of environmental Kuznets curve.

3.2.4. Granger Panel Causality Test

Granger causality test is performed to examine the causality between two variables. Granger causality test interpret the causality relationship based on two bases; the cause happens preceding to its effect and the cause has distinctive information in regard to the future values of its effect. In this estimation Granger Panel causality is performed. The test is based on Granger (1969) as cited in Lopez & Weber (2017) who instigated a way for examining the causal relationships between time series. Dumitrescu-Hurlin provide an extended test designed to detect causality in panel data. The underlying regression writes as follows:

$$y_{i,t} = \alpha_i + \sum_{k=1}^{K} \beta_{ik} y_{i,t-k} + \sum_{k=1}^{K} \gamma_{ik} x_{i,t-k} + \varepsilon_{i,t} \tag{8}$$

where $x_{i,t}$ and $y_{i,t}$ are the observations of two variables that must be stationary for individual i in period t. The coefficients can vary across individuals but assumed to not vary across time. It is further assumed that the lag order K is identical across all individuals and the panel is balanced (Lopez & Weber, 2017).

To sum up, the study analyses the relationships among CO2 emissions with economic growth, energy consumption, institutional quality, and foreign direct investment in these steps. First, it starts by detecting the integration levels of variables via Im, Pesaran, Shin (IPS) and Fisher type -Dicky Fuller panel unit root test. Then, panel cointegration test of Pedroni, Kao, and Westerlund are used to see the cointegration in the variables. The third step is the specification test for panel regression model using Wald test, LM test, and Hausman test to see which model is appropriate between pooled OLS, fixed effects, and random effects. After the appropriate model is determined, then the ling run cointegration test by FMOLS and DOLS are performed to further support the analysis. Then to investigate the environmental Kuznets curve, variable of log GDP per capita squared is added to the

FMOLS and DOLS model. Finally, Granger causality on panel data is used to see the causality between two variables.

4. Results

4.1. Panel Unit Root Test

In order to examine the stationarity of all the variables the study uses IPS and Fisher type-Dicky Fuller unit root test. The results of the Panel Unit root tests are shown in table 5. The results show that overall the variances across countries are stationarity at different levels and the variables are integrated at order one, this means that at some level all the variables are stationary in first difference. This means that for both IPS and Fisher type- Dicky Fuller the null-hypothesis is rejected as shown by the results in Table 5.

Table 5. Summary of Panel Unit Root Test

Im, Pesaran and Shin (IPS) Panel Unit Root Test		
Variables	Level	First Difference
ln CO2	0.3462	-16.8780***
ln GDP	-2.9587***	-14.9689***
(ln GDP)^2	-3.3964***	-14.5222***
ln EC	0.9031	-11.9735***
ln INT	-0.0581	-10.9555***
ln FDI	-3.4944 ***	-16.9036***
Fisher type - Dicky Fuller Panel Unit Root Test (P statistics)		
	Level	First Difference
ln CO2	16.4697	196.2510***
ln GDP	23.8193	126.3950***
(ln GDP)^2	28.5467*	130.7816***
ln EC	47.3503***	103.1120***
ln INT	67.9220***	197.1289***
ln FDI	50.7380***	164.3163***

Notes: (*), (**), (***) indicate significant at 10%,5% and 1% significance level respectively. Variable notations are on Table 2.

IPS: Ho: All panels contain unit roots; Ha: Some panels are stationary. Time trend is included, lags chosen by Akaike information criterion (AIC).

Fisher Type - Dicky Fuller: Performs the augmented Dickey-Fuller test that a variable follows a unit-root process. Ho: All panels contain unit roots; Ha: At least one panel is stationary Time trend is included, lags (1).

4.2. Panel Cointegration Test

This paragraph explains the panel cointegration tests results. The results are shown in Table 6. The results show that the null hypothesis of no cointegration of Pedroni test statistic is rejected as portrayed by the Phillips-Peron and Augmented Dicky-Fueller tests. The integration of the variables is further proved by the results of the Kao and Westerlund cointegration test. Therefore, it can be concluded that the variables have a strong degree of cointegration needed for the application of FMOLS and DOLS estimators.

Table 6. Panel Cointegration Tests

Pedroni test	Test statistics
Modified Phillips-Perron t	0.59
Phillips-Perron t	-3.46***
Augmented Dickey-Fuller t	-2.27**
Kao test	**Test statistics**
Modified Dickey-Fuller t	-2.76***
Dickey-Fuller t	-2.90***
Augmented Dickey-Fuller t	-3.29***
Unadjusted modified Dickey-Fuller t	-5.37***
Unadjusted Dickey-Fuller t	-3.84***
Westerlund test	**Test statistics**
Variance ratio	-2.06**

Notes: (*), (**), (***) indicate significant at 10%,5% and 1% significance level respectively. Variable notations are on Table 2. Pedroni test for cointegration: Ho: No cointegration; Ha: All panels are cointegrated. Kao test for cointegration: Ho: No cointegration; Ha: All panels are cointegrated. Westerlund test for cointegration: Ho: No cointegration; Ha: Some panels are cointegrated.

The specification tests are performed to see which model is appropriate for the panel regression. In these tests, we compare between pooled-OLS model, fixed effects, and random effects. The appropriate chosen model is used as the preliminary estimator before analyzing the long-term relationships and the existence of environmental Kuznets curve.

The first test is the modified Wald statistic for fixed effect estimation for groupwise heteroskedasticity in the residuals. The distributed Chi-squared as the outcome of test statistic is subject to the null hypothesis of homoskedasticity. The Wald Test in Table 7 shows that the null hypothesis is rejected and the model has heteroscedasticity, the Wald test denotes that we favor the fixed-effects model over the pooled-OLS model.

The next specification test is the Breusch-Pagan Lagrange Multiplier test. The null hypothesis Ho of Breusch-Pagan Lagrange Multiplier test is that the variance of the unobserved fixed effects is zero. We reject the Ho which means the variance of the random effect is zero: $Var(u_i) = 0$. This would mean that every variable has the same intercept $\tilde{\alpha} = \alpha + v$. The LM test is shown in Table 7. The results show that the random effects model is better suited to the data as compared to the pooled-OLS model.

Then the Hausman test is used to compare between the random effects and the fixed effects model. "The null hypothesis is that the individual and time-effects are not correlated with the x_{it}'s. The basic idea behind this test is that the fixed effects estimator is consistent whether the effects are or are not correlated with the x_{it}'s" (Hausman (1978) as cited in Jirata (2014), p. 13). In this case, we reject the Ho: difference in coefficients not systematic. The result of the Hausman test in Table 7 indicates that the fixed effect model is better suited to the random effect model. Therefore, the fixed effect model is employed as the preliminary estimator.

Table 7. Specification Tests for Panel Regression Model

	Wald Test	LM Test	Hausman Test
Test Statistics	Chi-Square	Breusch-Pagan	Chi-Square
	77.85***	296.22***	182.81***

Notes: (***) indicate significant at the 1% significance level.

4.3. Panel Regression Model

The fixed effects model is performed as a preliminary estimator before we run the long run estimators. Table 8 shows in the fixed effect models the variable of GDP for ASEAN countries is significant. Additionally, significant at 1% level of significance is showed by energy consumption variable. Institutional quality is statistically significant at 1% level of significance and in a similar way with foreign direct investment which is significant to carbon dioxide emissions. The results of the coefficients for GDP indicates a positive relationship of economic growth with the carbon dioxide emissions.

Table 8. Estimation of Fixed-effects Model

Dependent variable: ln CO2	Fixed-effects
Constant	-15.88*** (1.982)
ln GDP	0.355* (0.186)
ln EC	0.735*** (0.170)
ln INT	2.287*** (0.523)
ln FDI	0.0668*** (0.0162)
Observations	198

Notes: (*), (**), (***) indicate significant at 10%,5% and 1% significance level respectively. The estimation is in robust model.

4.4. Estimation of Long Run Cointegrating Relationship

To see the long run cointegrating relationship in the model, FMOLS and DOLS model are used. The results are shown in Table 9 where the long-run cointegration between the variables is confirmed. On the FMOLS estimation, GDP, EC, and INT have long run relationship with CO2 significant at 1% level of significance except for INT at 5% level of significance. Variable of FDI is not statistically significant. Based on DOLS estimation, only GDP and EC that have long run relation with CO2 while FDI and INT do not have long run relation to dependent variable of CO2.

Table 9. Estimation of cointegrating relationship by FMOLS and DOLS

Dependent variable: ln CO2	FMOLS	DOLS
Constant	-12.29*** (1.627)	-11.68*** (2.607)
ln GDP	0.753*** (0.216)	0.632* (0.330)
ln EC	0.634*** (0.234)	0.747** (0.337)
ln INT	0.642** (0.256)	0.541 (0.418)
ln FDI	-0.0397 (0.0635)	-0.0614 (0.121)
Observations	197	195

Notes: Variable notations are on Table 2. (*), (**), (***) indicate significant at 10%, 5% and 1% significance level respectively. Trend is included.

4.5. Environmental Kuznets Curve Analysis

Table 10 presents the results of the FMOLS and DOLS model for ASEAN countries. In this estimation, the variable of squared of log of GDP per capita is used to investigate the evidence of the environmental Kuznets curve. From the table, it is evident that the model does satisfy the condition of the environmental Kuznets curve hypothesis since the GDP variable and GDP per capita squared variable are significant. From the FMOLS model, the coefficient of the GDP is 3.124, the sign of the coefficient is positive and significant at 1% level of significance. It means that for a one unit increase in GDP, it would be expected a 3.124 unit increase in CO2. For variable squared of GDP, the sign is negative with the coefficient of -0.175 indicates that one unit increase in GDP after a certain threshold will decrease CO_2 by -0.175 unit. Similarly, with the coefficient of EC by 1.063 significant at 1% level of significance, an increase in one unit of EC will increase 1.063 unit in CO_2 as the dependent variable. However, in these results particularly in the FMOLS estimation it is found that variable INT and FDI have insignificant influence to CO_2.

On the DOLS model, the estimation shows similar findings with FMOLS. GDP coefficient is positive by 3.130 significant at 1% level of significance which specify that one unit increase in GDP will increase 3.130 in CO_2. Variable squared of GDP has negative sign of -0.175 so increase of unit GDP will decrease the CO_2 by -0.175. Moreover, positive sign is also attached to EC by 1.067 significant at 1% level of significance thus the increase of 1.067 unit CO_2 is caused by the increase of one unit of EC. Though, INT and FDI coefficients are statistically not significant in this model.

Table 10. Environmental Kuznets Curve, Estimation of FMOLS and DOLS Model

Dependent variable: ln CO2	FMOLS	DOLS
Constant	-19.78*** (0.868)	-19.90*** (1.408)
ln GDP	3.124*** (0.211)	3.130*** (0.316)
(ln GDP)^2	-0.175*** (0.0137)	-0.175*** (0.0201)
ln EC	1.063*** (0.0929)	1.067*** (0.142)
ln INT	-0.134 (0.113)	-0.119 (0.187)
ln FDI	-0.0148 (0.0243)	-0.0115 (0.0495)
Observations	197	195

Notes: *** indicates significant at the 1% level. Trend is included.

As DOLS model is providing less biased results, it is fascinating to further the analysis to examine if the significant coefficients of GDP and squared GDP formed an inverse U shaped. We investigate the presence of the shape by using the *utest* in Stata that evaluate the existence of a U shaped or inverse U shape relationship. Looking at Table 11 we can see that t-value is significant at the 1% level of significance. We reject the null hypothesis of the presence of monotone or U shape. This result shows that variable GDP and squared GDP formed an inverse U shape, further prove the existence of environmental Kuznets curve in ASEAN.

Table 11. Test for a U shaped Relationship

Specification: f(x)=x^2	
Overall test of presence of an Inverse U shape:	
t-value =	3.63***

Notes: *** indicates significant at the 1% level.
H0: Monotone or U shape; H1: Inverse U shape

Furthermore, as the presence of the inverse U shape is found, the turning point of the GDP per capita is calculated. If the coefficient on GDP is positive and the coefficient on squared GDP is negative, that suggests that GDP has a positive effect on CO2 until a turning point is reached. Beyond that value, GDP has a negative impact on CO2 which means environmental degradation lessen as the economy grow. The formula for calculating the turning point from regression coefficient based on DOLS is: $(-\beta_1/2*\beta_2)$[3] which is (-3.130/2*-0.175) = 8.943. After this calculation has been performed, we would check whether the resulting value falls within the range of GDP per capita or not. Then we calculate the exponential: exp (ln (GDP per capita)) to go back to the original metric. This procedure may approximate the value of the GDP per capita in its original metric. The calculation of the exponential is as follow: Exp (ln (8.943) = US$ 7645.125.

The result shows that the estimated turning point of GDP per capita is at US$ 7645.125 below the average but not too far US$ 7993.660 which mention in the summary statistics in Table 3. This might be indicating that group of countries in ASEAN in term of economic growth is not yet reaching the threshold beyond the income level but over time will have economic growth alongside decreasing environmental degradation that prove the existence of the environmental Kuznets curve hypothesis.

4.6. Granger Panel Causality

In order to understand long run causality and to analyze the cointegration between variables the study uses Granger Panel causality test on the variables of carbon dioxide emissions, GDP, energy consumption, institutional quality, and FDI. The results of this test are reported in Table 10. The results show that there is bidirectional causality between (1) CO2 and FDI, (2) GDP and FDI, and (3) INT and FDI. In addition, we have enough evidence to support one-way causality running from (1) GDP to CO2, (2) from CO2 to INT, (3) from GDP to INT, (4) from EC to CO2, (5) from EC to GDP, (6) from EC to INT, and (7) from EC to FDI. This one way causality from GDP to CO2 is similar with the findings of Halicioglu (2009), Niu et al. (2011), and Jalil & Mahmud (2009).

Table 12. Granger Panel Causality Results

Null Hypothesis	Zbar Stat.
ln CO2 does not Granger-cause ln GDP	0.4653
ln CO2 does not Granger-cause ln EC	0.1531
ln CO2 does not Granger-cause ln INT	6.4011***
ln CO2 does not Granger-cause ln FDI	2.5946***
ln GDP does not Granger-cause ln CO2	6.0662***

[3] β_1: coefficient of the linear term; β_2: coefficient of the squared term

Null Hypothesis	Zbar Stat.
ln GDP does not Granger-cause ln EC	1.1518
ln GDP does not Granger-cause ln INT	7.5997***
ln GDP does not Granger-cause ln FDI	3.6187***
ln EC does not Granger-cause ln CO2	5.2019***
ln EC does not Granger-cause ln GDP	2.3067**
ln EC does not Granger-cause ln INT	2.8053***
ln EC does not Granger-cause ln FDI	1.9589*
ln INT does not Granger-cause ln CO2	1.6183
ln INT does not Granger-cause ln GDP	0.8113
ln INT does not Granger-cause ln EC	0.0347
ln INT does not Granger-cause ln FDI	4.8565***
ln FDI does not Granger-cause ln CO2	4.3809***
ln FDI does not Granger-cause ln GDP	2.3338**
ln FDI does not Granger-cause ln EC	0.6078
ln FDI does not Granger-cause ln INT	10.1965***

(*), (**), (***) indicate significant at 10%,5% and 1% significance level respectively. The appropriate lag length is chosen by Akaike information criterion. Alternative hypothesis is dependent variable does Granger-cause independent variable for at least one panelvar.

5. Conclusion and Discussion

This study has made an effort to analyze empirically the relationships between CO2 emissions, income, energy consumption, institution and foreign direct investment for ASEAN From the results of the FMOLS and DOLS estimations, it shows the significance results of the variables GDP and GDP squared confirming that the environmental Kuznets curve hypothesis is valid consistent with Aruga (2019), Farhani et al. (2013), Jalil & Mahmud (2009), Niu et al, (2012), and Apergis (2006). The result implies that although most of ASEAN countries are in the lower-middle income group where they are in the phase of economic development, the environmental Kuznets curve hypothesis in this case is evident. It also implies the effort of the ASEAN region to reduce the carbon dioxide level. Therefore, it is assumed that in this case of ASEAN, as countries' economic growth has a tendency to increase, the environmental damage is presumed to decline which reasoned with the environmental Kuznets curve hypothesis. In spite of this, as this study is based on aggregate data, we cannot analyze the attempt of CO2 reduction by country level. Moreover, the one way causality from GDP to CO2 which similar with the findings of Halicioglu (2009), Niu et al. (2011), and Jalil & Mahmud (2009) suggested that as the income grow higher, more pollutions are emitted therefore this should receive attention from the policy maker to make use of appropriate regulation.

Furthermore, energy consumption is showing significant effect to carbon dioxide similar to findings by Halicioglu (2009), Jalil & Mahmud (2009), and Niu et al., (2011). The reason is because up until now, the most of the energy use relies on fossil fuel energy, therefore energy consumption is one of the major factors that contributes to pollution. From the findings of this study, it is found that energy consumption has one way causality to CO2. This one way long run causality from energy consumption to CO2 implies that it is a challenge for policy makers in ASEAN. As fossil fuel is the main source of energy use, it is suggested that the countries observed in this study consider the use of renewable energy in order to have less pollution coming from the energy consumption. For most developing countries, to have renewable energy source such as nuclear or solar energy is too costly in the initial construction. However, it is sustainable in the long term therefore these ASEAN countries should consider to invest in the renewable energy sources.

In addition, the quality of institutions variable shows that it has insignificant effect to pollution in the FMOLS estimation. The institutional quality variable is represented by Bayesian Corruption Index where the higher the index means the higher the corruption perception. However, since the coefficient variable is not significant, it has no effect to the dependent variable. It implies that in ASEAN in term of regional average, institutional quality does not have significant influence. Insignificant coefficient of institutional quality also found in Bhattacharya et al., (2017) study on the group of East Asia & Pacific and in the study of Carlsson & Lundström (n.d.). The finding is also consistent with Chang & Chang (2010) who discover that corruption is insignificant in countries with low level and high level of corruption. The results also may appear insignificant because of less variability in the quality of institutions variable.

In a similar manner with variable of institutional quality, foreign direct investment has no effect on the pollution of carbon dioxide which may imply that on the regional grouping, the level of foreign direct investment does not induce a raising impact on the pollution level in the investee countries. This finding is similar to study of Atici (2012) that found no support on FDI's detrimental effect on environments. However, the bidirectional causality result between CO2 and FDI is consistent to the result of Linh & Lin (2014). The notion that is proposed by the study of Linh & Lin (2014) is that there is bidirectional causality between FDI and CO2. They stated that "less stringent environmental regulations will attract FDI inflows, which will intensify environmental pollution" (Linh & Lin, 2014, p. 229).

This study naturally has limitations as it only focuses on the group of geographical region and only use certain estimators. For further research we propose to analyze the short-term dynamics and country level analysis. Further study may also include qualitative analysis on the development of the environmental law in ASEAN region and in country level or even provincial level. It is also suggested to look for other variables that might be meaningful to be included in the model such as income inequality, population density, access to electricity, access to renewable energy, average electricity price, and so on.

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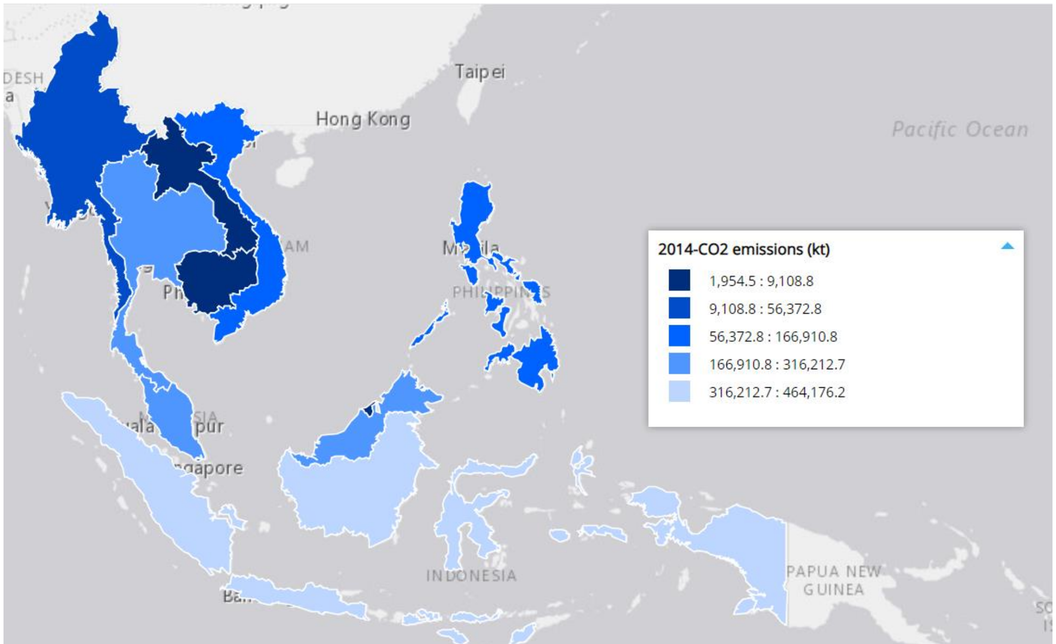
Appendices

Appendix 1

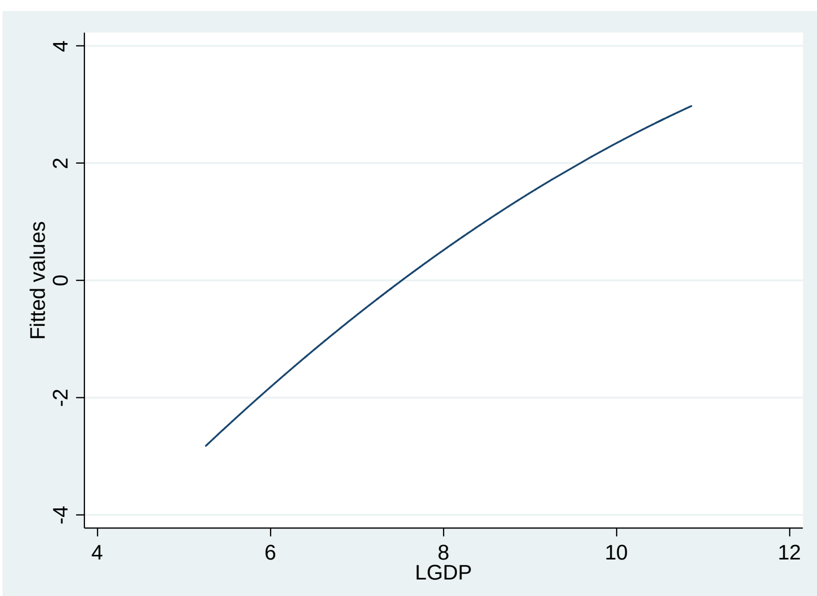
Distribution Map of Total CO2 Emissions in ASEAN by Country



Source: World Development Indicators, 2019

Appendix 2

Fit Plots Quadratic Prediction between ln CO2 and ln GDP



Source: Author's calculation

Appendix 3

Regression Results

Fixed Effects Regression

VARIABLES	LCO2
LGDP	0.355*
	(0.186)
LEC	0.735***
	(0.170)
LINT	2.287***
	(0.523)
LFDI	0.0668***
	(0.0162)
Constant	-15.88***
	(1.982)
Observations	198
Number of ccode	8
R-squared	0.780

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

FMOLS Cointegration Regression

Cointegration regression (FMOLS):

VAR lag(user)	= 0	Number of obs	= 197
Kernel	= bartlett	R2	= .8458762
Bandwidth(neweywest)	= 11.1712	Adjusted R2	= .8426652
		S.e.	= .561109
		Long run S.e.	= .7498473

LCO2	Coef.	Std.Err.	z	P>z	[95%Conf.	Interval]
LGDP	0.753	0.216	3.490	0.000	0.330	1.176
LEC	0.634	0.234	2.710	0.007	0.175	1.092
LINT	0.642	0.256	2.510	0.012	0.140	1.144
LFDI	-0.040	0.064	-0.620	0.532	-0.164	0.085
_cons	-12.287	1.627	-7.550	0.000	-15.475	-9.099

DOLS Cointegration Regression

Cointegration regression (DOLS)

AR lag(user)	= 0	Number of obs	= 195
Kernel	= bartlett	R2	= .9525421
Bandwidth(neweywest)	= 20.1685	Adjusted R2	= .9482762
DOLS lag(user)	= 1	S.e.	= .3223174
DOLS lead	= 1	Long run S.e.	= .9362634

LCO2	Coef.	Rescaled Std.Err.	z	P>z	[95%Conf.	Interval]
LGDP	0.632	0.330	1.910	0.056	-0.015	1.278
LEC	0.747	0.337	2.210	0.027	0.086	1.407
LINT	0.541	0.418	1.290	0.196	-0.279	1.360
LFDI	-0.061	0.121	-0.510	0.612	-0.299	0.176
_cons	-11.677	2.607	-4.480	0.000	-16.787	-6.567

FMOLS Regression for EKC

Cointegration regression (FMOLS):

VAR lag(user)	= 0	Number of obs	= 197
Kernel	= bartlett	R2	= .9793779
Bandwidth(neweywest)	= 2.9066	Adjusted R2	= .9788381
		S.e.	= .2068945
		Long run S.e.	= .2867688

LCO2	Coef.	Std.Err.	z	P>z	[95%Conf.	Interval]
LGDP	3.124	0.211	14.820	0.000	2.711	3.537
LGDP2	-0.175	0.014	-12.770	0.000	-0.202	-0.148
LEC	1.063	0.093	11.450	0.000	0.881	1.245
LINT	-0.134	0.113	-1.180	0.239	-0.356	0.089
LFDI	-0.015	0.024	-0.610	0.545	-0.062	0.033
_cons	-19.781	0.868	-22.780	0.000	-21.482	-18.079

DOLS Regression for EKC

Cointegration regression (DOLS):

AR lag(user)	= 0	Number of obs	= 195
Kernel	= bartlett	R2	= .9824867
Bandwidth(neweywest)	= 28.4577	Adjusted R2	= .9804737
DOLS lag(user)	= 1	S.e.	= .1980381
DOLS lead	= 1	Long run S.e.	= .3797731

LCO2	Coef.	Rescaled Std.Err.	z	P>z	[95%Conf.	Interval]
LGDP	3.130	0.316	9.910	0.000	2.511	3.749
LGDP2	-0.175	0.020	-8.720	0.000	-0.215	-0.136
LEC	1.067	0.142	7.490	0.000	0.787	1.346
LINT	-0.119	0.187	-0.640	0.525	-0.485	0.247
LFDI	-0.012	0.049	-0.230	0.816	-0.109	0.085
_cons	-19.897	1.408	-14.130	0.000	-22.657	-17.137