THE RELATIONSHIP BETWEEN ECONOMIC GROWTH, ENERGY CONSUMPTION AND TRADE WITH ENVIRONMENTAL DEGRADATION: THE CASE STUDY OF FIVE ASEAN COUNTRIES

By

BEHNAZ SABOORI

Thesis Submitted in Fulfillment of the Requirements for the Degree of Doctor of Philosophy

December 2013

ACKNOWLEDGEMENT

First and for most, I would like to express my sincerest thanks to my main supervisor, Professor Dato' Jamalludin Sulaiman for his encouragement, suggestions, guidance and great support throughout the period of my thesis writing. It was a real privilege and an honor for me to share of his vast knowledge but also of his extraordinary human quality. I have learned a lot from him. Without his help and support I could never have finished my thesis successfully.

Also, I would like to thank my Co-Supervisor Dr. Saidatulakmal Mohd for her support and constructive suggestions which has helped improve the quality of this thesis.

I will forever be thankful to my husband, Abdorreza Soleymani, who has always been encouraging me to achieve higher education. Without his love, courage and patience I will never have gotten to where I am today. I would like thank my daughter Saba for allowing me not to be with her for extended time to spend hours and days away while doing the research.

The last and surely the most important are my parents, Behjat Sheikholeslami and Mohammad Saboori whom I owe everything for who I am today. They show endless love, encouragement and unconditional support throughout my PhD years. Not forgetting the love, support and concern from my sisters Maliheh, Mahnaz and Mahsa and my brother Mohsen which has helped me to get all through the difficult times. So, I sincerely dedicate this thesis to all of them.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ACCI   ASEAN Climate Change Initiative

ADB   Asian Development Bank

ADF   Augmented Dickey-Fuller

AIC   Akaike's Information Criteria

AR   Autoregressive

ARDL   Autoregressive Distributed Lag

ASCC   ASEAN Socio-Cultural Community

ASEAN   Association of Southeast Asian Nations

ASOEN   ASEAN Senior Officials on the Environment

AWGCC   ASEAN Working Group on Climate Change

CDIAC   Carbon Dioxide Information Analysis Center

CFCs   Carbonated Fluorocarbons

CH4   Methane

CIA   Central Intelligence Agency

CO_2 Carbon Dioxide

CUSUM   Cumulative Sum

CUSUMSQ   Cumulative Sum of Squares

DOTS   Direction of Trade Statistics

EAS   East Asia Summit

EIA   Energy Information Administration

EKC   Environmental Kuznets Curve

ECM   Error Correction Model

EU	European Union
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GEMS	Global Environmental Monitoring System
GHG	Greenhouse Gas
HQC	Hannan Quinn Criterion
ICTs	Information and Communications Technologies
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
ISIC	International Standard Industrial Classification
KT	KiloTonne
LCB	Lower Critical Bound
MA	Moving Average
MYR	Malaysian Ringgit
N_2O	Nitrous Oxide
NAFTA	North America Free Trade Agreement
NMVOC	Non-Methanic Volatile Organic Compounds
NOx	Nitrogen Oxide
O_3	Ozone
OECD	Organization for Economic Cooperation and Development
OLS	Ordinary Least Square
PHH	Pollution Haven Hypothesis
PP	Philips-Perron

PPP	Purchasing Power Parity
RESET	Regression Equation Specification Error Test
SBC	Schawrtz Bayesian Criteria
SITC	Standard International Trade Classification
SPM	Suspended Particles Matter
SO_2	Sulfur Dioxide
TYDL	Toda, Yamamoto, Dolado and Lutkepohl
UN	United Nation
UCB	Upper Critical Bound
USD	United States Dollar
VAR	Vector Autoregression
VECM	Vector Error-Correction Model
WDI	World Development Indicator

HUBUNGAN ANTARA PERTUMBUHAN EKONOMI, PENGGUNAAN TENAGA, DAN PERDAGANGAN DENGAN DEGREDASI PERSEKITARAN: SATU KAJIAN DI LIMA BUAH NEGARA ASEAN

ABSTRAK

Kajian terbaru mengkaji keluk *Environmental Kuznets Curve* (EKC) menekankan tentang kurangnya atau pengabaian terus peranan penggunaan tenaga dan keterbukaan perdagangan dalam membentuk keluk EKC. Kajian-kajian empirikal sebelum ini, juga tidak mempertimbangkan kesan import dan eksport kotor dalam mengkaji model EKC. Kajian ini mengkaji hubungan antara pertumbuhan ekonomi dan pengeluaran karbondioksida (CO_2) berdasarkan ujian hipotesis EKC di lima buah negara ASEAN yang terpilih iaitu Indonesia, Malaysia, Filipina, Singapura, dan Thailand atau juga dikenali sebagai ASEAN-5. Kajian ini juga menyiasat kesan penggunaan tenaga keseluruhan dan keterbukaan perdagangan ke atas pengeluaran CO_2 oleh kelima-lima negara ASEAN ini dalam pembentukan EKC. Kajian ini seterusnya mengambil kira kesan import kotor ke atas negara ASEAN-5 dan eksport indusri kotor daripada negara ASEAN-5 ini kepada rakan perdagangan mereka dalam rangka kerja untuk mengkaji kesan *Pollution Haven Hypothesis* (PHH) ke atas kewujudan EKC. Dengan menggunakan pendekatan *Autoregressive Distributed Lag* (ARDL), model EKC kecil atau terhad tidak mampu menunjukkan hubungan antara pencemaran CO_2 dengan pertumbuhan ekonomi. Penggunaan tenaga dan keterbukaan perdagangan memainkan peranan signifikan dalam membentuk EKC di Malaysia, Singapura, dan Thailand. EKC di Singapura wujud berdasarkan model yang kecil atau terhad ini. Di Thailand, terdapat bukti bahawa EKC wujud setelah penggunaan tenaga dimasukkan ke dalam model.

Walaubagaimanapun, apabila model tersebut diperluaskan lagi dengan mengambil kira keterbukaan perdagangan, EKC dibuktikan turut wujud di Malaysia. Keputusan menunjukkan bahawa ada bukti jelas kegiatan melokasikan semula industri kotor kepada rakan dagangan utama Singapura dan Thailand dalam kajian ini. Oleh itu, PHH secara sedikit sebanyak nyata bertanggungjawab bagi kewujudan EKC di kedua-dua buah negara tersebut. Di Malaysia, kesan signifikan dagangan dalam membentuk EKC terutamanya disebabkan oleh eksport. Ini menunjukkan bahawa dari semasa ke semasa Malaysia telah mengurangkan eksport kotor kepada rakan-rakan dagangan terpilih utama mereka dalam kajian ini.Selain itu, EKC tidak wujud di Indonesia dan Filipina walaupun setelah memasukkan penggunaan tenaga dan keterbukaan perdagangan ke dalam model. Terdapat bukti ketara yang penempatan industri kotor ke Indonesia dan Filipina telah berlaku dalam perdagangan dua hala dengan rakan perdagangan utama mereka. Oleh itu, negara ASEAN-5 perlu membangunkan dasar-dasar yang mengambil kira isu alam sekitar dalam mengawal perdagangan yang melibatkan barangan import yang akan menjejaskan alam sekitar.

THE RELATIONSHIP BETWEEN ECONOMIC GROWTH, ENERGY CONSUMPTION AND TRADE WITH ENVIRONMENTAL DEGRADATION: THE CASE STUDY OF FIVE ASEAN COUNTRIES

ABSTRACT

Recent studies in examining the Environmental Kuznets Curve (EKC) emphasized the lack or even negligence of the energy consumption and trade openness role in shaping the EKC. Previous empirical studies, to certain degree have not considered the effect of dirty industry import and dirty industry export in examining the EKC model. This study examined the relationship between economic growth and CO_2 emissions based on the EKC hypothesis in the five selected ASEAN countries namely Indonesia, Malaysia, the Philippines, Singapore and Thailand or also known as the ASEAN-5. The study also investigated the effect of total energy consumption and trade openness on these ASEAN countries' emissions and in shaping the EKC. The study further included the effect of dirty industry import to the ASEAN-5 countries and dirty industry export from these countries to their main trading partners to the framework to examine the effect of Pollution Haven Hypothesis (PHH) on the existence of the EKC. Employing the Autoregressive Distributed Lag (ARDL) approach, the reduced-form EKC model was not able to demonstrate the accurate relationship between CO_2 emissions and economic growth. Energy consumption and trade openness played a significant role in shaping the EKC in Malaysia, Singapore and Thailand. In Singapore, the EKC existed based on the reduced-form model. In Thailand there was evidence of the EKC when energy consumption was included to the model. However, when the model was further extended by trade openness, evidence of the EKC also existed in Malaysia. The results revealed that, there were noticeable evidences of relocation of dirty industries to the

major trading partners of Singapore and Thailand. Thus, the PHH to some extent was responsible for the existence of the EKC in these two countries. In Malaysia, the significant effect of trade in shaping the EKC was mostly attributed to the export. This implies that over time, Malaysia has reduced its dirty export to its selected major trading partners. On the other hand, the EKC did not exist in Indonesia and the Philippines even with the inclusion of energy consumption and trade openness to the model. There was noticeable evidence of dirty industry relocating to Indonesia and the Philippines through bilateral trade with their main trading partners. Thus, the ASEAN-5 countries need to develop policies to consider the environmental concerns in regulating free trade to control imports of environmental damaging goods.

1   CHAPTER ONE: INTRODUCTION

1.1   Introduction

Climate change or global warming is one of the most serious environmental threats of the 21st century. It is the only global environmental problem that receives the attention of heads of states and governments. Scientific researches by the Intergovernmental Panel on Climate Change (IPCC) predict millions of people will confront shortage of food and water and a greater risk to quality of life due to the climate change. IPCC also identified that developing countries are among the most vulnerable regions to climate change due to the lack of social, technological and financial resources (IPCC, 2007).

The Southeast Asian region which comprised mostly of developing countries is already affected by climate change and the worst is yet to come (IPCC, 2007). There are a number of factors that make the region more vulnerable to the climate change. A seminal study conducted by the Asian Development Bank (ADB) in 2009 listed them as follows; rapid population growth (2 percent annually) compared with the global average (1.4 percent); long coastlines; high concentration of population and economic activities in coastal areas; heavy reliance on agriculture for providing livelihoods and high dependence on fisheries, natural resources and forestry in many of its countries (ADB, 2009)

Carbon dioxide (CO_2) emissions which is responsible for about 60 percent of the greenhouse effect (Ozturk & Acaravci, 2010a), significantly contribute to the warming of global temperatures and climate change (IPCC, 1997). The IPCC's fourth assessment report shows that along-observed trend in declining global CO_2 emissions intensity per

unit of Gross Domestic Product (GDP) reversed about the year 2000 (IPCC, 2007). This means that global CO_2 emissions have grown the most rapidly from 1970 to the present (Halicioglu, 2009). Every region and country contributes different amounts of CO_2 to the atmosphere. While there is a drop in the share of CO_2 emissions in Organization for Economic Cooperation and Development (OECD) countries (from 60 percent in 1960 to 43.5 percent in 2007), the share of CO_2 emissions in Southeast Asian region has increased from 1.4 percent in 1960 to 6 percent in 2009.[1]

Economists believe that economic growth will be a cure for global environmental challenges. The economic perspective is assumed that the environmental degradation first increases with economic growth and development then decouples from it and finally decreases when income reaches a certain high level. This inverted U-shaped relationship between environmental degradation and economic growth was first named the EKC by Panayotou (1993). The EKC hypothesis describes the time path of environmental degradation which a country will follow as economic development proceeds. The EKC hypothesis has been examined by a large number of researchers after the three following path breaking studies: Grossman and Krueger (1991); Shafik and Bandyopadhyay (1992) and Panayotou (1993). All of them tried to answer the question whether economic growth is a solution for or a cause of environmental problems and tried to estimate the changes of environmental quality over time (Kijima, Nishide, & Ohyama, 2010).

Understanding the structural mechanisms of pollution trends during the process of economic growth for each country individually is crucial for many reasons. First,

---

[1] Calculated based on World Development Indicators (WDI) database of World Bank
(http://www.worldbank.org/)

economic growth and its consequences on the environment are inseparable. Economic activities harm the environment in the form of air and water pollution, natural resources extraction, biodiversity loss and the greenhouse effect. Most pollutant emissions reached a maximum level between 1960 and 1985 and subsequently decreased due to the implementation of abatement measures. An exception is the Greenhouse Gas (GHG) emissions which the EKC does not seem to exist for them (Sari & Soytas, 2009). Second, economic growth is mainly driven by structural change and technological progress which both can be pollution-increasing and pollution-saving at the same time. This increase in income on the one hand may allow society to spend more on abatement and on the other hand, may encourage the investment in potentially polluting activities. As a result of these relationships, the fundamental question arises of whether economic growth without excess pollution is possible in the long-run. Third, the studies (Shafik, 1994; Grossman & Krueger, 1995; Selden & Song, 1994) that examined the EKC hypothesis showed that environmental degradation will stop at the per capita income of 4000 USD and above.[2] Does this mean that developing countries should tolerate the environmental degradation until reaches the per capita GDP of 4000 USD and above? Finally, if the EKC exists, economic growth can be as a solution for environmental problems over time. Thus, the estimated turning point (the level of income in which the environmental degradation starts to decrease) is a key factor to design the development and environmental strategies.

Dinda and Condoo (2006) argued that developed economies have to forgo income growth and developing countries have to sustain their economic growth to reduce carbon emissions. Some parts of the growth of CO_2 emissions are attributed to economic

---

[2] Per capita income measured in Purchasing Power Parity (PPP) in 1985 US dollar.

growth therefore the reduction in CO_2 emissions at the cost of economic growth may not necessarily be a desirable outcome (Lotfalipour, Falahi, & Ashena, 2010).

According to the EKC hypothesis, economic growth is a possible solution for environmental problem. CO_2 emissions are considered the main causes of global warming; thus, whether the EKC exists for CO_2 emissions has become a crucial topic in environmental economics. Although, empirical literature results with respect to the inverted U-shaped relationship between CO_2 emissions and per capita income are vast, they are inconclusive.

The vast majority of available empirical literatures concentrated on using the cross-country panel data, thus they could not examine the impact of environmental policies, historical experiences and other exogenous factors through time. These studies provided a general understanding of how the variables are related and they are not able to offer much guidance for policy implication for each country individually (Ang, 2008). The lack of a common EKC for all the countries justifies the need to carry out individual countries studies to enable them choose their own path of sustainable development. The major advantage of individual country studies is bringing the analysis closer to the dynamic (Lindmark, 2002). The EKC is a phenomenon as it depicts the development trajectory for a single economy that grows through different stages over time (Dinda, 2004).

Another reason for the increasing CO_2 emissions is the level of energy consumption. It is well recognized that reducing energy consumption is the direct way of managing the emissions problem. However, reducing energy consumption may have negative impacts on economic growth. Economic growth is closely related to energy consumption as

4

countries with high energy consumption often show higher economic development. Combustion of fossil fuels is the largest contributor to CO_2 emissions. Since fossil fuels have been accounted for a major part of the total commercial energy consumption in ASEAN countries, about 90 percent, the larger the amount of commercial energy consumption the greater is the CO_2 emissions (Karki, Mann, & Salehfar, 2005). For example Southeast Asian region's GHG emissions from the energy sector increased by 83 percent during 1990-2000, the highest among the major emission sources (ADB, 2009). Reduction of energy consumption can decrease the GHGs emissions but at the same time may have a negative impact on economic growth. This is the reason why most of developing countries are hesitant to keep with the Kyoto Protocol targets yet.

Since, most of the researches consider the growth–environment nexus and growth–energy nexus in a bivariate framework, thus suffer from omitted variables bias, hence a study of both nexuses in a single framework is necessary. Moreover, a large number of empirical studies suggested that the link between environmental degradation, economic growth and energy consumption in different countries is not unique. Therefore examining the dynamic relationship among them for each country individually is necessary.

Along with economic growth and energy consumption, there is another reason for increasing CO_2 emissions which is under the definition of the pollution haven hypothesis (PHH). It suggests emissions reductions in nations with high environmental regulation is partly the result of shifting dirty production to countries with low environmental standard. The hypothesis suggests that countries with low environmental regulations attract pollution intensive industries from countries with stringent

environmental regulations. Based on the PHH, as openness proceeds, developing countries may therefore increasingly specialize in pollution intensive production and would change to net exporters of pollution intensive goods and deteriorate their environmental quality. The impact of real bilateral movement of pollution-intensive goods and services between countries on CO_2 emissions especially in developing countries is very important.

So far most of the studies that examined the relationship between economic growth and environmental degradation, concentrated on the simple form of the EKC and they did not account for trade patterns and the PHH. While there are some researchers who have incorporated the impact of trade policy orientation and trade openness on the EKC, the impact of real bilateral movement of pollution-intensive goods and services between countries has not been considered yet. Since each pollution-intensive industry corresponds to different amount of CO_2 emissions, employing aggregate trade data may firstly bias the coefficients of GDP and may secondly neglect the important effects of import and export from different industries on CO_2 emissions. Therefore, investigating the evidence of the PHH and assessing the effects of trade patterns in each dirty industry between a country and her trading partners on CO_2 emissions is crucial.

1.2 The ASEAN Region at Glance

The Association of Southeast Asian Nations (ASEAN) was established on 8 August 1967 in Bangkok, with the signing of the ASEAN declaration by the five original member nations namely Indonesia, Malaysia, the Philippines, Singapore and Thailand. Since then, membership has expanded to include Brunei Darussalam, Vietnam, Laos,

6

Myanmar and Cambodia making up what is today the ten member states of ASEAN which all of them are in Southeast Asia.

Table 1.1 gives an overview of the main economic indicators of the ASEAN's members. The region has a total land area of 4.326 million square kilometers (3.3% of the world's land area) and a long coastline about 173,000 kilometers and rich natural resources like marine life and abundant mineral resources.

Table 1.1 ASEAN Economic Indicators, 2011

Countries	GDP per capita [a]	Economic growth [b]		Area (sq. km)	Population	Population growth rate [c]	Urban population (% of total)		
		1990-1999	2000-2011				1970	2000	2011
Brunei	17,301	2.08	1.58	5,270	405,938	3.21	62	72	76
Cambodia	590	7.25	8.03	176,520	14,305,183	1.91	16	19	20
Indonesia	1,207	4.83	5.31	1,811,570	242,325,638	1.91	17	42	51
Laos	592	6.27	7.09	230,800	6,288,037	2.13	10	22	34
Malaysia	5,345	7.25	5.01	328,550	28,859,154	2.49	33	62	73
Myanmar	-	6.12	-	653,290	48,336,763	1.65	23	27	33
Philippine	1,413	2.75	4.67	298,170	94,852,030	2.55	33	48	49
Singapore	33,529	7.31	5.93	700	5,183,700	2.33	100	100	100
Thailand	2,699	5.28	4.04	510,890	69,518,555	1.85	21	31	34
Vietnam	757	7.42	7.11	310,070	87,840,000	1.82	18	24	31
ASEAN	63,433	5.7	5.4	4,325,830	597,914,998	2.185	33.3	44.7	50.1

Sources: World Development Indicator (WDI) database of World Bank
a Constant 2000 US$
b Average annual growth rate (percentage)
c Average population growth rate (annual percentage from 1960 until 2011)

ASEAN is one of the fastest growing economic regions in the world. Its economy has experienced rapid growth at an average annual rate of 5.7 and 5.4 percent from 1990 until 1999 and 2000 until 2011, respectively. Singapore has the highest GDP per capita followed by Malaysia, Thailand, the Philippines and Indonesia. However in terms of GDP, Indonesia ranks first, followed by Thailand, Malaysia, Singapore and the Philippines. The region's economy is expected to continue to grow at 4.9 percent by 2020. The region has a total population of 598 million in 2011 which is about 8.6 percent of the total world population. Population density is high in megacities such as Jakarta, Kuala Lumpur and Manila at about 10,000 people per square kilometer.

Most of the ASEAN nations (Indonesia, the Philippines, Viet Nam, Thailand, Myanmar and Malaysia) are among the top 50 most populous countries in the world. The highest population growth rate belongs to Brunei (3.21) followed by the Philippines (2.55), Malaysia (2.49), Singapore (2.33) and Laos (2.13) in 2011. In 1970, around 33 percent of the region's total populations were living in urban areas and this increased to 45 percent in 2000 and 50 percent in 2011. The urban population is projected to increase to 55 percent by 2020.

1.3　Energy Outlook in the ASEAN Countries

ASEAN's rapid economic and population growth especially in urban areas increased demand for energy consumption which was registered at 3.6 percent per annum from 1995 to 2007. About 90 percent of the total primary energy requirement is fulfilled by fossil fuel resources such as coal, oil and gas. The combustion of fossil fuels will increase environmental pollutants specifically CO_2 emissions.

1.3.1 Energy Consumption

High economic and population growth rate in ASEAN countries resulted in a substantial increase in final energy consumption. The average annual growth rate of the total ASEAN final energy consumption was 3.9 percent over the period of 1995-2010. With the assumed GDP and population growth rate, the final energy consumption is estimated to increase at an average annual rate of 4.4 percent in 2030 (The Third ASEAN Energy Outlook, 2011), higher than the world's average annual growth rate of 1.4 percent per year in energy demand over 2008-2035 (Birol, 2010).

By sector, the industrial sector had the fastest growth rate in energy consumption (6.1 percent) followed by transport sector (3.5 percent) and residential, commercial and non-energy sectors (2.2 percent). The industrial sector contributed about 23 and 29 percent of the total ASEAN energy demand in 1995 and 2007, respectively (Figure 1.1). It is estimated that industrial sector will contribute about 34.5 and 36 percent of the total region energy demand by 2020 and 2030, respectively.
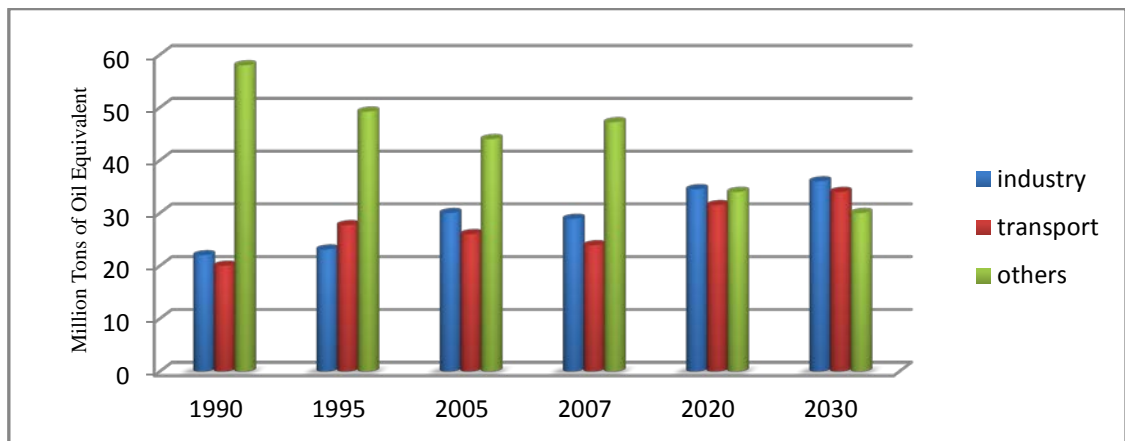
Figure 1.1: ASEAN Final Energy Consumption and its estimation by Sector

Source: The Third ASEAN Energy Outlook, 2011

In terms of fuel, final consumption of coal was the fastest growing fossil fuels consumption at an average annual rate of 14 percent. This growth is attributed to the growth of the industrial sector. The second fastest growing fuel was natural gas having an average annual growth rate of 9.9 percent. Electricity was the third fastest growing fuel having increased at an average annual rate of 6.6 percent (Figure 1.2).
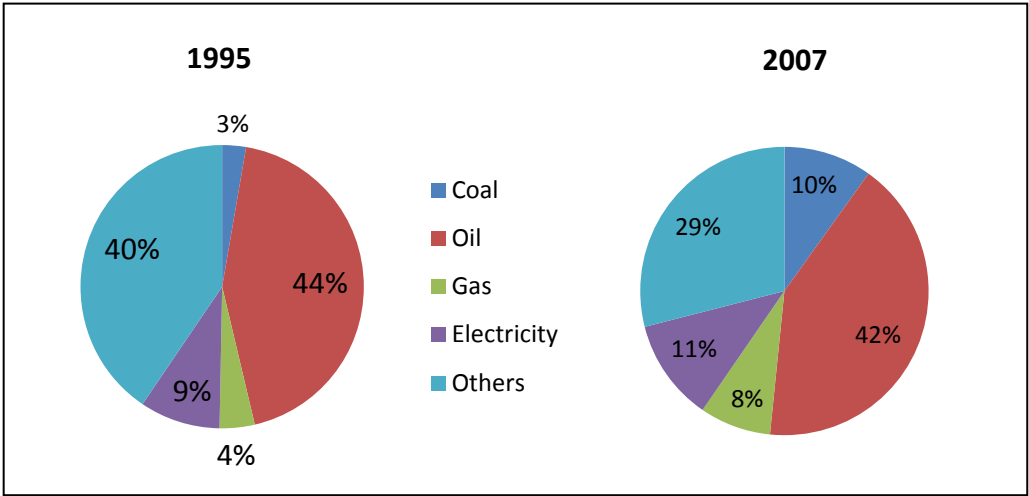
Figure 1.2: ASEAN final energy consumption by fuel, 1995 and 2007

Source: The Third ASEAN Energy Outlook, 2011

Figure 1.2 shows that from 1995 to 2007 coal had the fastest growth followed by gas and electricity consumption. Greater use of Information and Communications Technologies (ICTs) will change ASEAN energy consumption mix to more electricity consumption.

1.3.2 Energy Supply

Energy supply in ASEAN has increased from 252 Million Tons of Oil Equivalent (MTOE) in 1990 to 489 MTOE in 2005 and 511 MTOE in 2007 (IEA database). [3] This is an average increase of 4.2 percent per annum over the 1990 to 2007 period. Table 1.2 illustrates the increasing trend of primary energy supply in some ASEAN countries. Malaysia experienced the highest growth rate in her total primary energy supply from 1990 to 2009 followed by Vietnam, Thailand, Indonesia, Singapore and the Philippines.

Table 1.2: Total primary energy supply in the five selected ASEAN countries (MTOE)

Country	1990	1995	2000	2005	2007	2008	2009	% changes 1990-2009
Indonesia	101.3	135.0	155.7	181.4	188.3	191.8	202	99.4
Malaysia	22.0	37.1	47.3	62.6	69.5	73.0	66.8	203.9
Philippines	28.9	34	40.4	39.2	38.1	39.6	38.8	34.4
Singapore	11.5	18.6	19.2	18.6	15.7	16.7	18.5	61.3
Thailand	41.9	61.9	72.4	96	102.2	106.3	103.3	146.3
Vietnam	24.3	30	36.9	51	56	59.1	64	163.6

Data source: IEA database

In the ASEAN countries, fossil fuels remain the major source of energy supply. Among all fuels, coal grew fastest during the period 1990-2007 at almost 11.5 percent per annum (The Third ASEAN Energy Outlook, 2011). This is mainly because of the rapid growth in industrial sector, rapid increase in electricity consumption and coal-fired power plants. Oil and gas supply will grow annually by 4.4 and 3.2 percent, respectively

---

[3] International Energy Agency (IEA), available at https://www.iea.org/stats/

11

until 2030. The share of electricity in total ASEAN energy supply will increase from 11 percent in 2005 to 18.2 in 2030 (The Second ASEAN Energy Outlook, 2009).

1.3.3   Electricity Generation

The electricity generation mix in ASEAN has changed from 1995 to 2007. About 81.4 percent of ASEAN's electricity generation was fulfilled by fossil fuels such as coal, oil and gas in 1995 and it increased to 83.8 percent in 2007. The share of coal increased from 13.4 percent in 1995 to 27.3 percent in 2007. The share of oil decreased from 31.4 percent to 10.6 percent while the share of gas increased from 36.7 percent to 45.9 percent (IEA database). These changes in the shares of coal, oil and gas could be attributed to the reduction in the oil generation electricity and oil independence policies. Furthermore, for the ASEAN members, coal and natural gas are cheaper fuel sources for electricity generation. Electricity generation in this region also increased from other sources such as geothermal, wind, solar and biomass, although their combined shares remained low, only slightly increasing from 0.1 percent in 1995 to 0.7 percent in 2007. While the rapid increase in the use of ICTs, such as personal computers, telecommunication equipment, sound, video and image recording and reproducing apparatus and printed circuits that require considerable electricity input have placed increased pressure on electricity generation.

1.4   Environmental Status in the ASEAN Countries

1.4.1   Carbon Dioxide Emissions

The major greenhouse gases (GHG) emissions are carbon dioxide (CO_2), methane (CH4) and nitrous oxide (N_2O). Among them CO_2 emissions is a global pollutant with the largest contribution from human activities (IPCC, 2007). It is responsible for about 60 percent of the greenhouse effect (Ozturk & Acaravci, 2010a).

Global CO_2 emissions have increased steadily. Base on the World Development Indicator (WDI) database of World Bank, Southeast Asian countries contributed to the problem of climate change by producing CO_2 emissions that accounted for 4.83 percent of global CO_2 emissions in 2009 while it was about 1.2 percent in 1965 (WDI database). However, ASEAN's CO_2 emissions are still quite low compared to industrialized countries and regions, but it is increasing at an annual average rate of 5.6 percent. For example ASEAN's total CO_2 emission from the combustion of fossil fuels, manufacture of cement and gas flaring in 1995 was about 0.61 billion metric tons of CO_2 equivalent, but have increased to about 0.99 billion metric tons in 2005 (ASEAN, 2009). According to Carbon Dioxide Information Analysis Center (CDIAC) in 2008, Indonesia ranked the 15th, Thailand 22nd, Malaysia 27th, Vietnam 33rd and the Philippines 42nd in total anthropogenic CO_2 emissions among countries of the world while, Brunei Darussalam, Cambodia and Lao PDR have low levels of total emissions. Figure 1.3 shows the trend of CO_2 emissions in the five selected ASEAN countries for the period 1960-2009. As can be seen from the figure, the CO_2 emissions have an increasing trend in all ASEAN members and projected to continue to do so (IEA statistics, 2011).
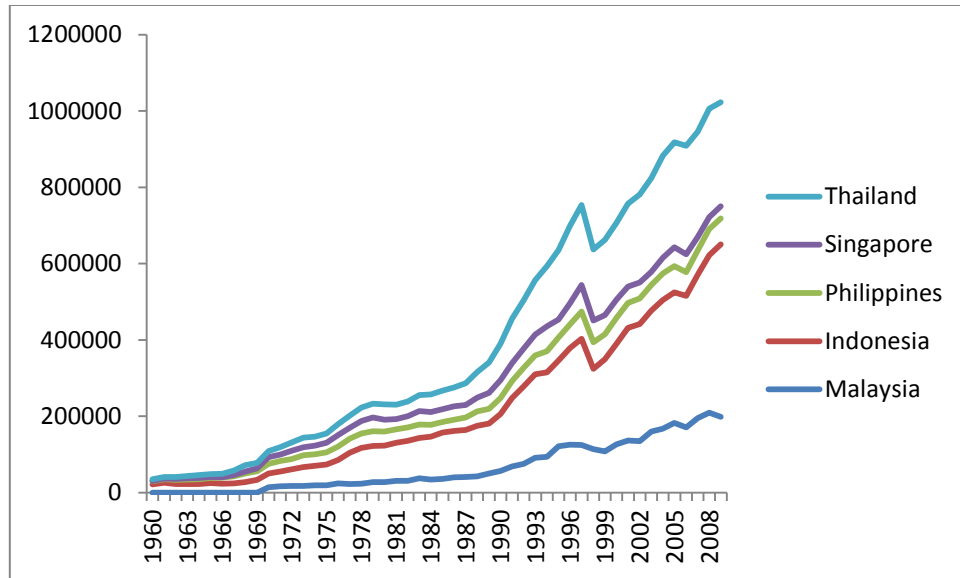
Figure 1.3: CO$_2$ emissions in the ASEAN countries KiloTonne (KT)

Source: World Development Indicators (WDI) database of World Bank

The increases in CO$_2$ emissions is mainly because of the annual escalation of coal consumption projected at 7.7 percent, which is the most carbon-intensive fossil fuel, 4.4 percent annual growth rates in oil and the 3.2 percent in natural gas consumption. Coal and natural gas are more used in electricity generation for industries and oil in the transportation. Table 1.3 shows the total CO$_2$ emissions from fossil fuels combustion in ASEAN countries and its corresponding growth.

Table 1.3: Total Carbon Dioxide Emissions from the Combustion of fossil fuels in the five selected ASEAN countries (Million Metric Tons)

Country	Fuel sources	1990	2000	2005	2009	% changes 90-09
Indonesia	Oil	94.51	154	183.6	178.53	88.90
	Gas	45.74	64.11	49.92	84.27	83.27
	Coal	15.73	48.13	97.08	152.1	86.69
Malaysia	Oil	39.06	62.82	71.93	76.18	75.18
	Gas	20.77	45.79	53.99	59.74	58.74
	Coal	5.15	8.855	21.68	13.69	12.69
Philippines	Oil	35.94	51.48	51.48	44.98	43.98
	Gas	0	0.018	0.018	6.454	-
	Coal	5.45	19.38	19.38	20.61	19.61
Singapore	Oil	57.63	104.7	120.9	137.38	136.38
	Gas	0	2.943	12.97	18.95	-
	Coal	0.1	0.002	0.009	0.018	-0.982
Thailand	Oil	58.68	94.24	136.9	127.05	126.05
	Gas	11.04	36.52	59.6	71.7	70.7
	Coal	14.21	30.99	45.32	56.13	55.13
Vietnam	Oil	7.84	26.23	36.46	41.84	40.84
	Gas	0.077	2.953	8.395	14.84	13.84
	Coal	8.93	16.93	31.43	41.65	40.65

Source: Energy Information Administration (EIA) database

As can be seen from Table 1.3, selected countries are experiencing an increasing trend in CO_2 emissions from fossil fuels combustion. The CO_2 emissions from fossil fuels combustion is significantly higher in Indonesia followed by Thailand, Singapore, Malaysia, Vietnam and the Philippines.

1.4.2   Climate Change Impacts in the ASEAN Countries

The issues of global warming and climate change are the most crucial environmental challenges of the 21st Century and it has attracted more attention all over the world since the last decades. The IPCC reported for the period 1995-2006, it ranked among the 12 warmest years in instrumental record of global surface temperature since 1850. It

reported a 1.1 to 6.4 °C increase of the global temperatures by 2100 (IPCC, 2007). Because of global warming, snow cover and mountain glaciers have declined and have caused the sea level to rise. A rise in the sea level of about 16.5 to 53.8 centimeters by 2100 was reported by IPCC in 2007.

Although global warming is a serious danger to all countries, some countries are vulnerable due to their special physical, economic and social environment. ADB in 2009 reported that Southeast Asian region has been affected by climate change more than the global average. The ASEAN region is one of the vulnerable regions to the impact of climate change. About 43 percent of the workforce is involved in forestry and agricultural activities. A great number of people live and concentrate on fast growing cities along the coastlines and rivers (ADB, 2009).

Climate change is already affecting Southeast Asia with rising temperature, decreasing rainfall, sea-level rise [4], increasing frequency and intensity of extreme weather events leading to massive flooding, tropical storms, landslides and drought causing extensive damage to property, assets, and human life, high risk on the ecological security of mangroves and coral reefs and extinction of many species of mammals and birds and a large population of many other species.

1.5   Trade and Carbon Dioxide Emissions in the ASEAN Countries

International trade has always been the engine of economic growth in ASEAN countries since its creation in 1967. Most of the member countries experienced rapid economic growth through industrialization and export-led growth. This enabled ASEAN countries

---

[4] The ADB predicts that sea levels may rise by 70 centimeters (27 inches) by the end of this century in some parts of Southeast Asia where four in five people live within 65 miles of the coast (ADB, 2009).

to move away from resource based industries to manufacturing and heavy industries. They promoted this by accepting foreign direct investment from developed countries such as Japan, the USA and EU countries, which have been the major investors in the region (WDI database).

Since much of the rise in trade is in manufactured parts and components, especially in the electronics and automotive sectors, the region is the center of the global manufacturing. This may have a significant effect on the energy consumption in the region. In terms of trade openness (import plus export divided by GDP) Singapore with the value of 392.64 stands in the first place following by Malaysia, Thailand, the Philippines and Indonesia with the value of 207.64, 125.82, 106.59 and 56.93, respectively in 2003 (Heston, Summers, & Aten, 2006).

ASEAN rapid industrialization especially the rapid increase in use of information and ICTs, such as personal computers, telecommunication equipment, sound, video and image recording and reproducing apparatus and printed circuits that are more energy intensive sectors, has increased the consumption of fossil fuels for energy generation such as coal, oil and gas (Karki *et al*., 2005). Since about 90 percent of ASEAN's primary commercial energy requirement is satisfied by fossil fuels, there is more pressure on the GHG emissions especially CO_2 emissions. Table 1.4 shows the trade patterns in the five selected ASEAN countries. A constant increase in the share of major ASEAN countries in total nonoil trade (trade net of oil and gas) from 1969 until 2008 is apparent.

Table 1.4: The ASEAN-5 countries in world trade (percent)

Country Name	Total (nonoil) Trade			Manufacturing Trade			Manufacturing Share in Total Exports/Imports		
	1969/70	1989/90	2007/8	1969/70	1989/90	2007/8	1969/70	1989/90	2007/8
Export sector									
Indonesia	0.3	0.5	0.9	0	0.4	0.6	3.8	55.6	41.5
Malaysia	0.8	1	1.6	0.1	0.7	1.6	7.2	60.4	70.9
Philippines	0.5	0.3	0.6	0.1	0.3	0.6	10.3	62.8	83.8
Singapore	0.2	1.1	1.2	0.1	1.3	1.4	45.9	91.2	70.6
Thailand	0.3	0.8	1.3	0	0.6	1.3	7.7	59.6	76.5
Import sector									
Indonesia	0.4	0.7	0.6	0.5	0.8	0.6	80.7	83	57.7
Malaysia	0.5	1	1.1	0.5	1	1.1	63.9	85.6	72.3
Philippines	0.5	0.4	0.4	0.6	0.3	0.4	77.3	76.4	65.3
Singapore	0.9	1.9	1.9	0.9	2.1	2.1	63.7	87.4	68.6
Thailand	0.5	1.1	1.1	0.7	1.1	1.1	85.9	84.1	68.5

Source: Athukorala (2011)

Focusing on the manufacturing trade, a notable shift towards manufacturing trade is observable across all economies at varying speed and intensity. However a significant lower share of manufacturing in their import is evident in almost all countries.

Despite the economic transformation of the ASEAN-5 countries from agriculture and primary exporters to manufactured exporters over the past decades, most of their major trading partners have remained unchanged. The USA, Japan, ASEAN, China and EU were the top five trading partners of the ASEAN-5 in 2010, contributing about 68 percent of total trade of ASEAN-5 (Figure 1.4).
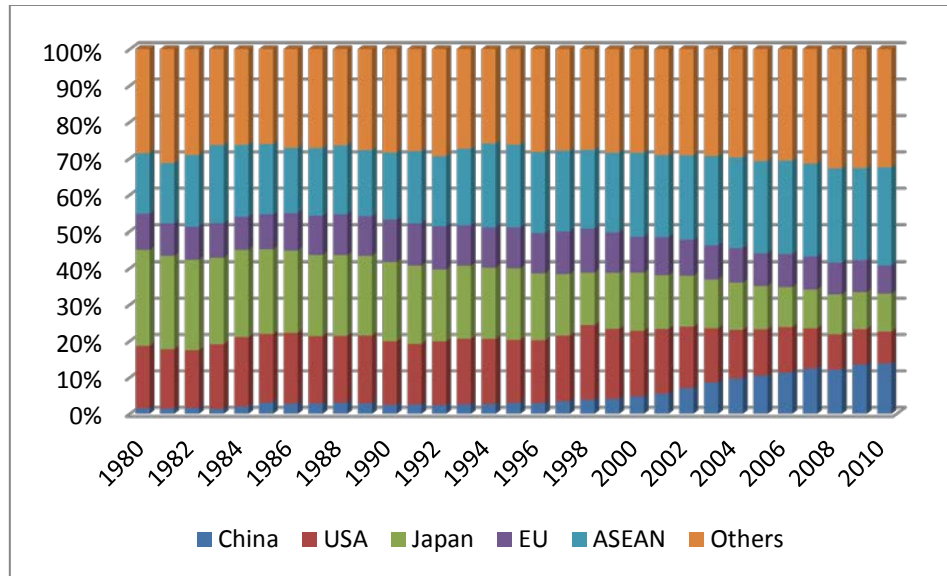
Figure 1.4: Trade share of the ASEAN-5 with its major trading partner countries/regions (1980-2010)

Source: International Monetary Fund, Direction of Trade Statistics (DOTS)

Table 1.5 shows the main trading partners and the main export and import commodities for the five selected ASEAN countries in 2010. Today, more developed countries in ASEAN region produce high technology-intensive intermediate goods to be sent to less developed ASEAN countries for assembly and finally the final products will be exported to all over the world. Thus, electrical appliances, semiconductors, electronic products, machinery and equipment are among the main import and export commodities. Japan as the top trading partner of Indonesia, contributes 15 percent to Indonesia's total trade in 2010. This is followed by China (12.7 %), Singapore (11.9%) and the USA (8.3%). In the case of Malaysia, China as the top trading partner, contributes 13 percent to Malaysia's total trade. This is followed by Singapore, Japan and the USA. For the Philippines, Japan, the USA, Singapore and China are the main trading partners in 2010.

19

Malaysia, China, the USA and Indonesia are the main trading partner of Singapore. Thailand's main trading partners are Japan, china, the USA and Malaysia.

Table 1.5: Major trading partners and major import and export commodities in Indonesia, Malaysia, the Philippines, Singapore and Thailand in 2010

Country	Major Trade Partner	Main Export Commodities	Main Import Commodities
Indonesia	Japan (15%) China (12.7%) Singapore (11.9%) United states (8.3%) South Korea (7.1%) Malaysia (6.3%) India (4.6%) Thailand (4.2%)	oil and gas electrical appliances plywood textiles rubber	machinery and equipment chemicals fuels foodstuffs
Malaysia	China (13%) Singapore (12%) Japan (11%) United states (10%) Thailand (5.7%) South Korea (4.2%) Taiwan (3.5%) Indonesia (3.1%) India (2.5%) Philippines (1.7%)	electronic equipment petroleum & liquefied natural gas wood and wood products palm oil rubber textiles chemicals	Electronics, machinery, petroleum products, plastics vehicles iron & steel products chemicals
Philippines	Japan (14%) United states (13%) Singapore (12%) China (9.7%) Hong Kong (5.5%) Thailand (5.3%) Taiwan (5.1%) Malaysia (3.7%) Germany (3.5%) Indonesia (2.6%)	semiconductors & electronic products transport equipment garments copper products petroleum products coconut oil fruits	electronic products mineral fuels machinery & transport equipment iron & steel textile fabrics grains chemicals plastic
Singapore	Malaysia (11.8%) China (10.6%) United states (8.69%) Indonesia (7.53%) Hong Kong (6.66%) Japan (6.16%) South Korea (4.88%) Taiwan (4.73%)	machinery and equipment (including electronics) pharmaceuticals & other chemicals mineral fuels	machinery and equipment mineral fuels chemicals foodstuffs
Thailand	Japan (15.5%) China (12.1%) United states (8.16%) Malaysia (5.64%) Singapore (4.05%) Australia (4.04%) Hong Kong (3.93%) Indonesia (3.45%)	textiles and footwear computers and electrical appliances fishery products rice rubber jewelry automobiles	capital goods intermediate goods & raw materials fuels

Reference: Central Intelligence Agency (CIA), The World Factbook

1.6   Problem Statement

ASEAN countries experienced a five percent yearly growth in its economy over the period from 1980 to 1999 and is expected to sustain this growth rate from 2007 to 2020. The region's economic growth led to a consequential increase in primary energy consumption (3.6 percent per annum from 1995 to 2007).[5] With the assumed GDP and population growth rate, the final energy consumption is estimated to increase at an average annual rate of 4.4 percent in 2030, comparing to the world's average annual growth rate of 1.4 percent over the period 2008-2035 (Birol, 2010).

ASEAN-5 countries economic growth is well-known for its heavy reliance on international trade. For decades, the industrialized countries such as Japan, the USA and the EU have been their most important trading partners. Trade with countries with different environmental standards may have changed these countries to specialize in pollution intensive production and over time become net exporters of pollution-intensive goods. As a result, the region experienced a major shift in the composition of export from agriculture-based to manufacture and industry-based commodities. Electronics components and parts including semiconductors and ICTs have accounted for a major part of ASEAN's manufacturing exports.

The production of these goods that require substantial electricity input have increased the pressure on electricity generation. About 81.4 percent of ASEAN's electricity generation required fossil fuels such as coal, oil and gas in 1995 and in 2007 it has increased to 83.8 percent. This increasing consumption of fossil fuels for electricity

---

[5]The Third ASEAN Energy Outlook, 2011

generation will have a corresponding increase in CO_2 emission which is said to contribute to global warming.

Since fossil fuels accounted for a major part of the total energy consumption in ASEAN, about 90 percent, the larger the amount of energy consumption the greater is the CO_2 emissions (Karki *et al*., 2005). The growth in primary energy consumption will result in a corresponding 5.7 percent growth in CO_2 emissions, which worsens the climate change and its impacts in the region. Increase in CO_2 emissions is mainly because of the projected 7.7 percent annual escalation of coal consumption which is the most carbon-intensive fossil fuel, 4.4 percent annual growth rates in oil and the 3.2 percent in natural gas consumption. Coal and natural gas are more used in electricity generation for industries and oil in transportation sector.

Since there is a strong relationship among economic growth, energy consumption, foreign trade and CO_2 emissions, therefore this relationship has important implications for economics, trade and environmental policies. So far most of researches consider growth-environment, trade-environment, growth-energy relationships in bivariate frameworks thus suffer from omitted variables bias; hence a study of all relationships in a single framework is necessary. This will shed light to the question whether economic growth without excess pollution in the five selected ASEAN countries is possible in the long-run.

As trade in each industry corresponds to different amount of CO_2 emissions, an empirical analysis of each industry trade effect on CO_2 emissions is very important in policy making decisions and implementation of trade and environmental policies. This allows an improvement of investment regimes in the five selected ASEAN member

states in order to increase flow of foreign investments for clean and energy efficient technologies.

1.7   Research Questions

The present study proposes the following questions:

1. Is economic growth without excess pollution possible in the short and long-run in Indonesia, Malaysia, the Philippines, Singapore and Thailand?

2. What is the effect of energy consumption on CO_2 emissions in the five selected ASEAN countries in the short and long-run?

3. Does EKC hypothesis exist when the role of energy consumption is included to the model?

4. What is the effect of trade openness on CO_2 emissions in the five selected ASEAN countries in the short and long-run?

5. Does EKC hypothesis exist when the role of trade openness is included to the model?

6. How does the estimated turning point of EKC for CO_2 emissions affect by including the role of energy consumption and trade openness?

7. What is the effect of trade in dirty industries on ASEAN-5 countries' CO_2 emissions with each of their main trading partners in the long-run?

8. Does EKC exist in ASEAN-5 countries after including dirty industries export and import data to the model?

9. Is PHH responsible for determining the EKC in the five selected ASEAN countries?

10. Does PHH exist in dirty industries in the five selected ASEAN-5 countries?

1.8 Objectives

The general objective of this study is to examine the existence of the EKC in Indonesia, Malaysia, the Philippines, Singapore and Thailand for CO_2 emissions. The specific objectives of this study are:

1. To investigate the dynamic relationship between economic growth and CO_2 emissions in the five selected ASEAN countries.

2. To investigate the dynamic relationship between economic growth, CO_2 emissions and energy consumption and to examine the effect of energy consumption on CO_2 emissions and in shaping the EKC in ASEAN-5 countries.

3. To investigate the dynamic relationship between economic growth, CO_2 emissions, energy consumption and trade openness and to examine the effect of trade openness on CO_2 emissions and in shaping the EKC in ASEAN-5 countries.

4. To investigate the effect of dirty industries import and export on CO_2 emissions and in shaping the EKC in ASEAN-5 countries.

5. To test the Pollution Haven Hypothesis (PHH) in the five selected ASEAN countries.

1.9 Significance and Contribution of the Study

This research adds significant contribution to the existing literatures. Most of the previous studies considered the relationship between economic growth and CO_2 emissions or economic growth and energy consumption in a bivariate framework thus,

24