CO_2 EMISSION, ECONOMIC GROWTH AND ENERGY CONSUMPTION FOR ASEAN-3 COUNTRIES: A COINTEGRATION ANALYSIS

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DECLARATION

We hereby declare that:

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

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

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

(4) The word count of this research is 12,473 words.

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey-Fuller
ARDL	Autoregressive Distributed Lag
ASEAN	Association of Southeast Asian Nations
CNLRM	Classical Normal Linear Regression Model
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CUSUM	Cumulative Sum
CUSUMQ	Cumulative sum of Squares
CV	Critical Value
ECM	Error Correction Model
ECT	Error Correction Term
EKC	Environmental Kuznets Curve
ENG	Energy Used
EP	Environmental Pressure
GDP	Gross Domestic Product
GHG	Green House Gases Emission
IEA	International Energy Agency
IPCC	Intergovernmental Panel Climate Change
JB	Jarque- Bera
JJ	Johansen and Juselius
KPSS	Kwiatkowski-Phillips-Schmidt-Shin

NAFTA	North American Free Trade Agreement
NO_2	Nitrogen Dioxide
NO_x	Oxides of Nitrogen
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
P-value	Probability value
PP	Phillips-Perron
RESET	Ramsey Regression Specification Error Test
RGDP	Real Gross Domestic Product
R&D	Research and Development
SBC	Schwartz Bayesian Criterion
SO_2	Sulfur Dioxide
SPM	Suspended Particulate Matter
SURADF	Seemingly Unrelated Regressions Augmented Dickey Fuller
UK	United Kingdom
USA	United States of America

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Abstract

This paper examines the long-run relationship between carbon dioxide (CO_2) emission, real gross domestic product (RGDP), and energy used using a time series data for ASEAN-3 countries (Indonesia, Philippines, and Singapore) over the period of 1974-2009. Autoregressive Distributed Lag Model (ARDL) and bound testing approach are used in this study to examine the cointegration relationship. A cointegration relationship exists in all the countries studied. Also, energy used is identified to be a significant variable in determining the carbon dioxide emission. Besides, the square of RGDP is included to identify the existence of Environmental Kuznets Curve (EKC). This study does not support the EKC hypothesis for ASEAN-3 countries. Moreover, lagged error correction terms (ECTs) are measured to be significant and negative. In other words, the short-run has been adjusted back to long-run equilibrium. Overall, in order to reduce carbon dioxide emission and to increase energy efficiency and at the same time augmenting energy conservation policies to abate unnecessary energy wastage are necessary. Some recommendations are also suggested in this study for future researches.

CHAPTER 1: RESEARCH OVERVIEW

1.0 Introduction

Civilization and advancement is mankind's continuous pursuit. Through years of civilization, the world has come a long way to the development human being enjoy today, be it culturally, politically or economically. Economic growth is possibly one of the most widely used yardsticks to measure the status and wellbeing of any nation. Unfortunately, to achieve the comfort and luxuries mankind savour today, it seems almost inevitable that economic growth comes with a price of destruction on Earth's environment. Human activities had led to various environmental problems and pollution, notably global warming.

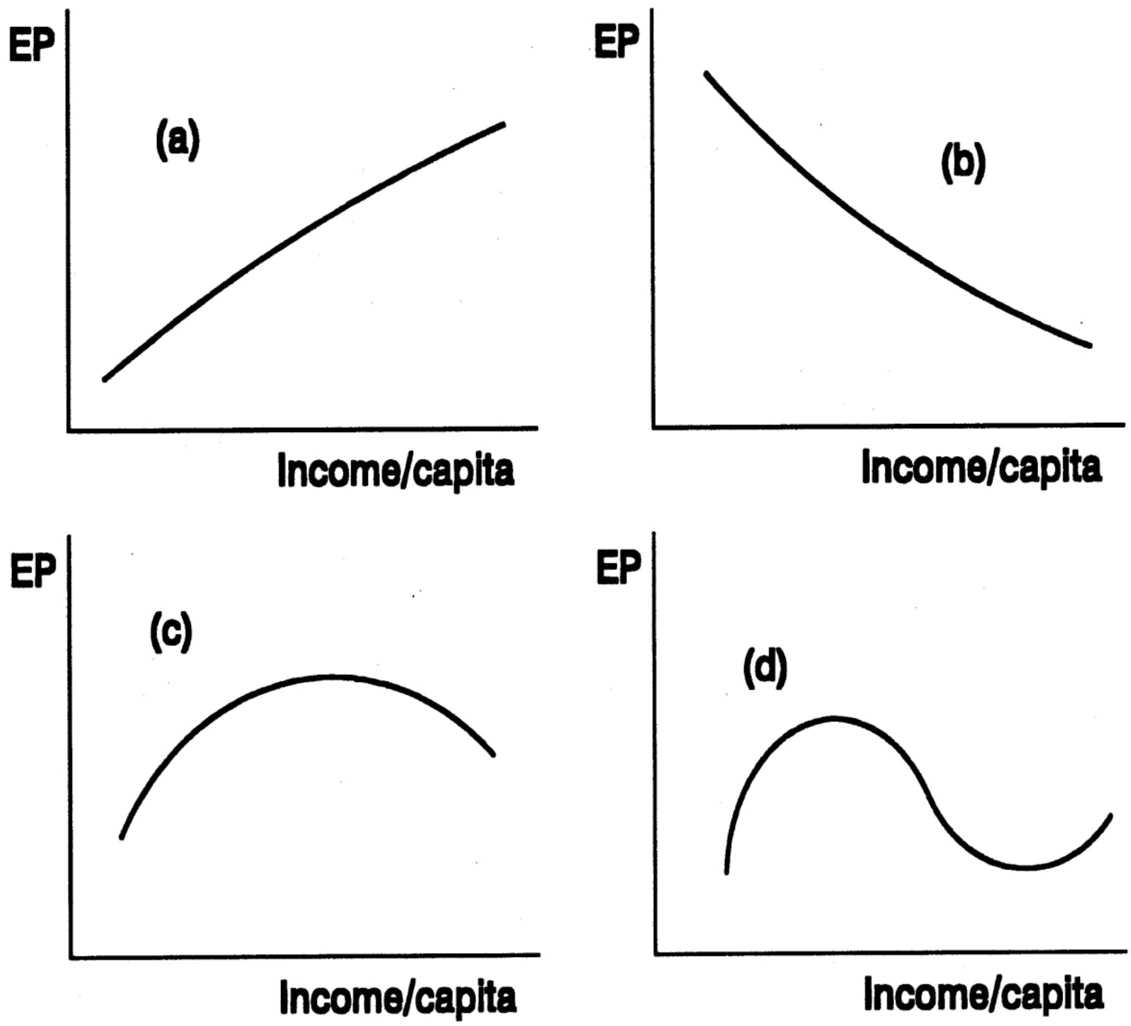
The relationship between economic development and environmental quality has always been an area of interest of researchers, even more now with the world moving towards sustainable growth. Economic growth plays an important role in determining environmental quality (Copeland & Taylor, 2004; Dasgupta, Hamilton, Pandey & Wheeler, 2006; Stern, 2004). Besides, energy used is also important in determining environmental quality as Arouri, Youssef, M'henni, and Rault (2012) suggested that there is a relationship between energy consumption and Carbon Dioxide (CO_2 hereafter) emission. Panayotou (2003), Selden and Song (1994), and Stern (2004) suggested that the relationship between certain types of Environmental Pressure (EP hereafter) and economic growth follow the Environmental Kuznets Curve (EKC hereafter) upon their research using different types of pollutants. Besides, increasing or decreasing relationship between environmental quality and economic growth is found in de Bruyn, van den Bergh, and Opschoor (1998). Through this study, it was found that most of the past researches done were on developed countries or better known as Organization for Economic Co-operation and Development (OECD hereafter) (de Bruyn et al., 1998; Grossman & Krueger, 1995; Kee, Ma & Mani, 2010; Panayotou, 2003;

Tsurumi & Managi, 2010), while very minimal attention has been paid to the Asian countries and developing nations such as Malaysia, Thailand, Philippines and Indonesia.

CO_2 emission is one of the many environmental indicators used in such research. Over the years, the level of CO_2 emission in the atmosphere has substantially increased and quickly became a main contributing reason to the global warming phenomena. Excessive CO_2 emission level in the atmosphere is the main cause of global warming (Florides & Christodoulides, 2009; Vlek, Rodriguez-kuhl & Sommer, 2004). According to Intergovernmental Panel Climate Change of the United Nations (IPCC), greenhouse effect is mainly caused by CO_2 emission where this phenomenon of increased in temperature is resulted from the absorption of outgoing infrared radiation by water vapour, CO_2, methane, and other atmospheric gases. The consequences of continuous increase in temperature on Earth may get even more detrimental beyond expectations, because the increase in global temperature will lead to a rising in sea level and the amount and pattern of precipitation will magnify the chance of extreme weather events, changes in agricultural yields, species extinctions, and even more (Florides & Christodoulides, 2009).

The relationship between economic growth and environmental quality is appeared as inverted U-curve which is similar to the pattern between economic growth and income inequalities which is found by Kuznets (1955). This hypothesis when apply in the study of relationship between economic growth and environmental quality is known as the EKC. EKC hypothesized that in the early stage of economic development, environmental degradation increases as the economy develop, and however, it will decrease when a certain level of national income is achieved. Over the years, researchers found that EKC can be depicted in four curves which are the monotonic curve and non-monotonic curve. Under monotonic curve, increasing trend may appear in the relationship between increasing pollution and rising income (Figure 1.0 a) or decreasing trend showing decreasing pollution with rising income (Figure 1.0 b). For non-monotonic curve, relationship between pollution and income may appear in inverted-U and N-shaped curve (Figure 1.0 c & d). When longer time horizons are taken into account, more complex patterns of curve may present. In short, the patterns rely on the types of pollutants and the model that have been used for estimation (de Bruyn et al., 1998).

Figure 1.0: Various Relationships between EP and Income Per Capita



Source: S.M. de Bruyn et al (1998).

This study seeks to examine the long-run relationship between Real Gross Domestic Product (RGDP hereafter), energy used and CO_2 emission in 3 selected Association of Southeast Asia Nations (ASEAN-3 hereafter) countries which include Indonesia, Philippines and Singapore.

1.1 Research Background

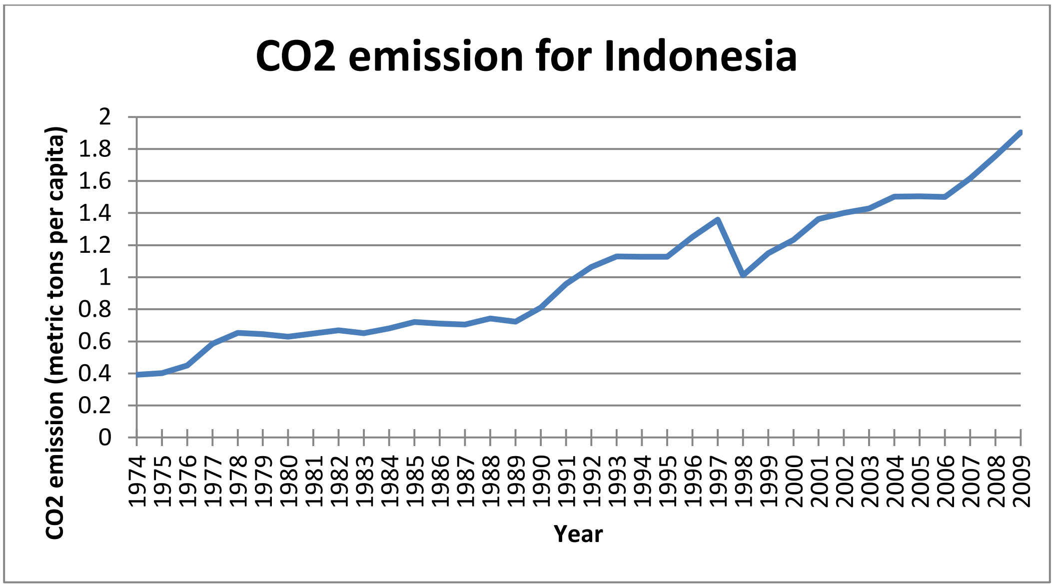
The Association of Southeast Asia Nations (ASEAN hereafter) consists of 10 countries from Southeast Asia jointly established with the purpose to prosper, to promote economic growth, social progress, and cultural development in the region. Rapid economic growth in ASEAN increase energy consumption which subsequently increase various emissions from power generation plants, cement factories, oil refineries, agricultural-based industry, chemical plants, and wood-based industries (Lean & Smyth, 2010). According to Karki, Mann, and Salehfar (2005), fossil fuel resources (coal, oil, and gas) fulfill about 90 percent of the total commercial primary energy requirement of ASEAN. The combustion of fossil fuels and biomass in transport, industry, agriculture, and households releases huge amounts of environmental pollutants. Thus, CO_2 emission in the region is increasing; although, comparatively lower than industrialized countries like the United States (Karki et al., 2005).

The reasons of study ASEAN-3 countries in this study are due to the highest economy growth in the world over the last three decade and regarded as the most influential ASEAN members (Lean & Smyth, 2010). Indonesia is the largest archipelagic state in the world with very high rate of urbanization which ranked fourth in the world as most populated country. Urbanization and industrialization is the important determinants of CO_2 emission, economic growth, and energy used. Meanwhile, Singapore has the highest income level among all ASEAN countries. Economic growth is one of the variables used in this study paper to determine CO_2 emission thus it is crucial to examine whether high income level will exhibit high CO_2 emission. Philippines has experienced more frequent flooding that cause the agriculture in the country damage (Chen & Li, 2007, as cited in Lean & Smyth, 2010). Flooding is one of the consequences of greenhouse effect (Florides & Christodoulides, 2009) therefore it is necessary to include Philippines and at the same time the countermeasure of reducing the consequences of greenhouse effect can be taken in the country.

In the subsequent section, CO_2 emission, RGDP, and energy used in each of the chosen country will be explained in details.

1.1.1 Indonesia

Figure 1.1: CO_2 Emission for Indonesia

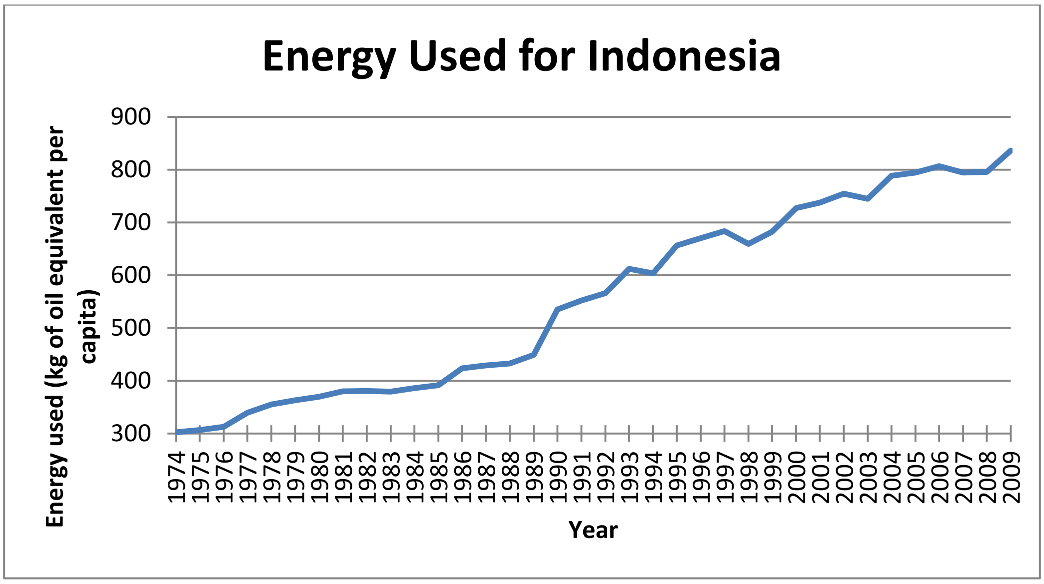


Source: Retrieved January 31, 2013 from World Bank's World Development Indicator (http://www.worldbank.org/), own illustration.

Figure 1.2: RGDP for Indonesia

Source: Retrieved January 31, 2013 from World Bank's World Development Indicator (http://www.worldbank.org/), own illustration.

Figure 1.3: Energy Used for Indonesia



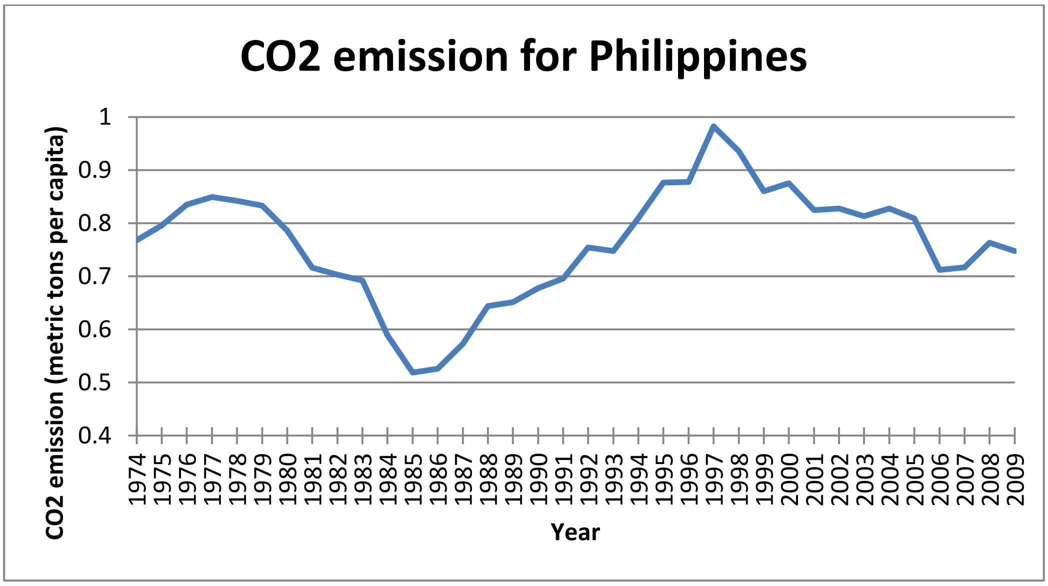
Source: Retrieved January 31, 2013 from World Bank's World Development Indicator (http://www.worldbank.org/), own illustration.

Indonesia is the larger country in ASEAN that is also geographically isolated from other member countries (Karki et al., 2005). Indonesia with one of the world's second largest tropical forest has one of the fastest deforestation rate in the world and ranked third in greenhouse gases emission (Jafari, Othman & Nor, 2012). Indonesia is a primary producer of wood furniture, with intense deforestation and also often has some of the worst forest fires. It is known fact that, deforestation, any other form of activities and event that can severely affect the habitat in the forest will affect the ecosystem. From 1980 to 2001, CO_2 emission for Indonesia grew the fastest among all ASEAN countries due to the development of energy intensive industries in the country (Energy Information Administration, 2004).

Based on Figure 1.1 to 1.3, Indonesia's CO_2 emission, RGDP, and energy used show an increasing trend. High level of urbanization and industrialization in the country is the primary cause of the increasing energy used (Karki et al., 2005), RGDP, and higher emission. It should be noted that forest fires in Indonesia usually occurs during the mid of the year (Sastry, 2002). In the year of 1997, forest fire in Indonesia which lasted long into 1998 was probably one of the worst forest fires in history which had caused serious air pollution, the spreading of thick smoke, and haze to Southeast Asia (Sastry, 2002).

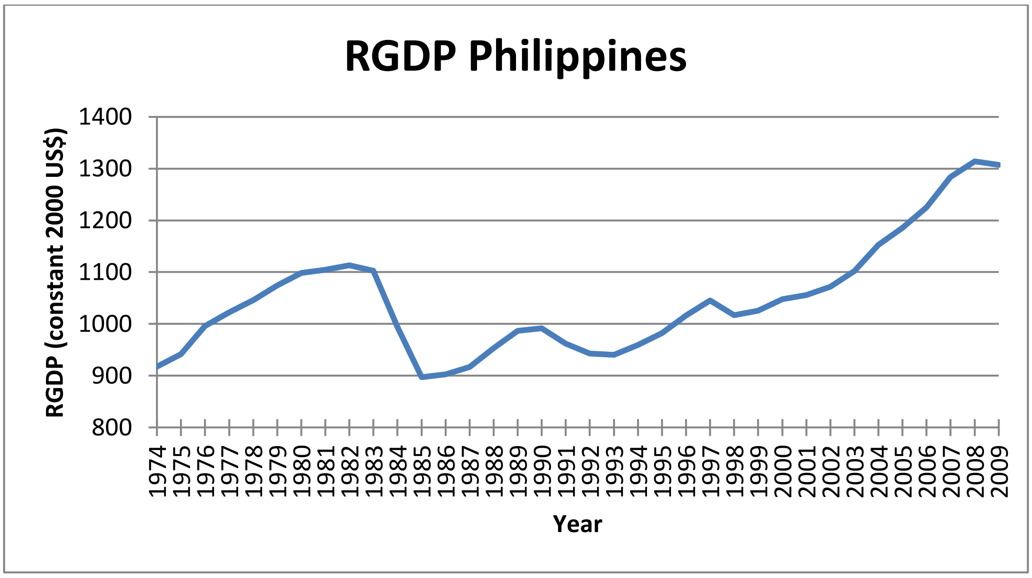
1.1.2 Philippines

Figure 1.4: CO_2 for Philippines



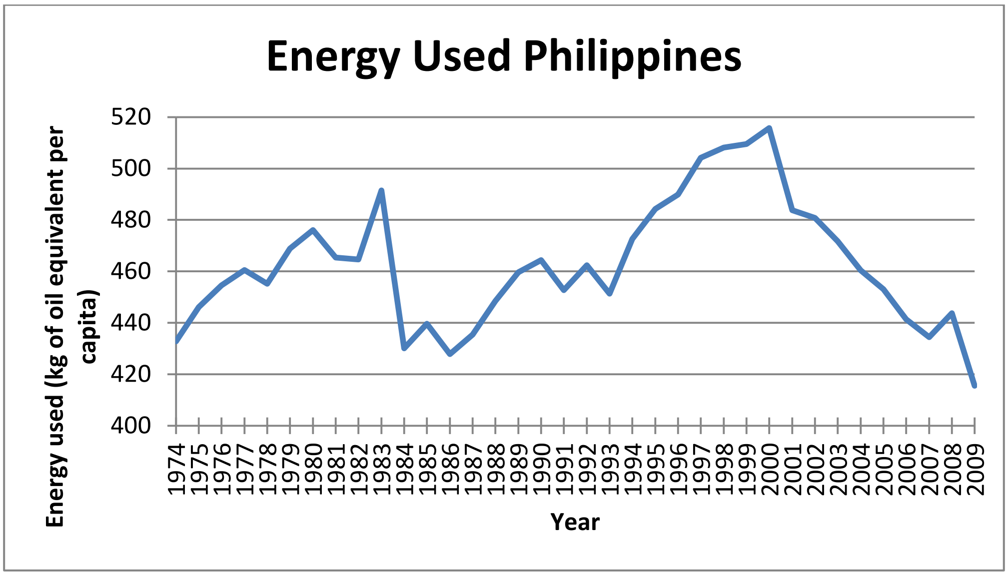
Source: Retrieved January 31, 2013 from World Bank's World Development Indicator (http://www.worldbank.org/), own illustration.

Figure 1.5: RGDP for Philippines



Source: Retrieved January 31, 2013 from World Bank's World Development Indicator (http://www.worldbank.org/), own illustration.

Figure 1.6: Energy Used Philippines



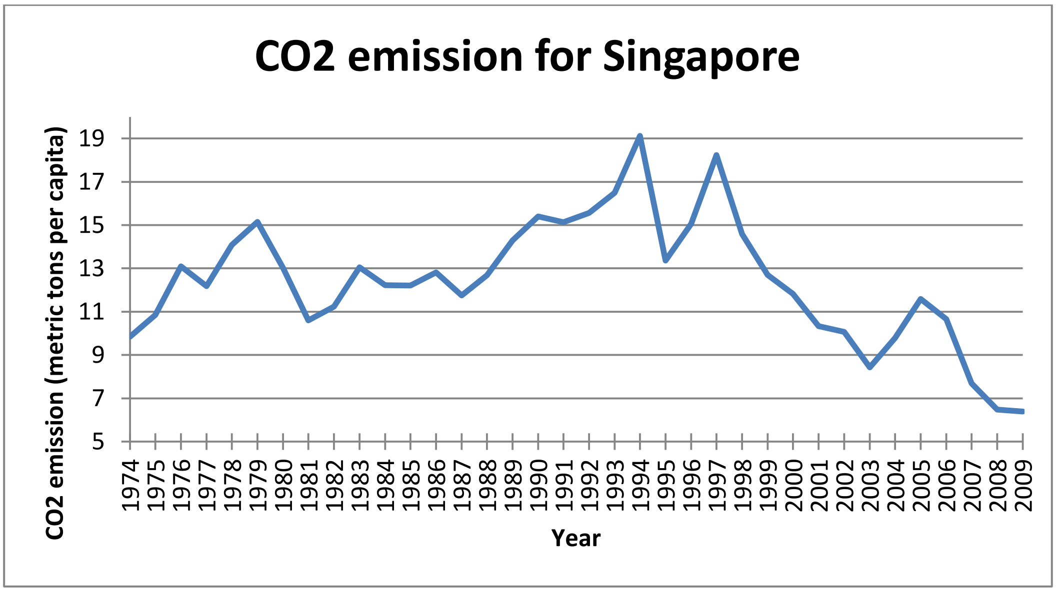
Source: Retrieved January 31, 2013 from World Bank's World Development Indicator (http://www.worldbank.org/), own illustration.

Philippines as a newly industrialized country, is slowly transitioning from a country based on agriculture to one which is based more on services and manufacturing. This transition definitely brings about the increase in CO_2 emission in Philippines. It should be noted that, a very interesting factor of CO_2 emission in Philippines is indoor air pollution, which was found to be caused by incomplete burning of biomass and coal as the people in Philippines cooks using traditional cook stoves. As much as 90% of the biomass is consumed in the household sector (Bhattacharya, 2000, as cited in Karki et al., 2005).

The 1992 power shortage in Philippines brought some of the greatest harm to the country's economy and this caused the RGDP to drop in year 1992. RGDP illustrated in Figure 1.5 shows that Philippines's RGDP experiences a sharp drop from year 1983 to 1985 and has the lowest RGDP in year 1985. This is mainly due to the Philippines crisis in 1984. The crisis had caused serious impact on the country's economy such as adverse terms of trade, rise in public sector deficit, and balance of payment problem (Malin, 1985). Besides the Philippines crisis, Asian financial crisis also has an impact on Philippines' economy. From the Figure 1.4 and 1.6, CO_2 emission and energy used for Philippines show a similar trend of fluctuation over time.

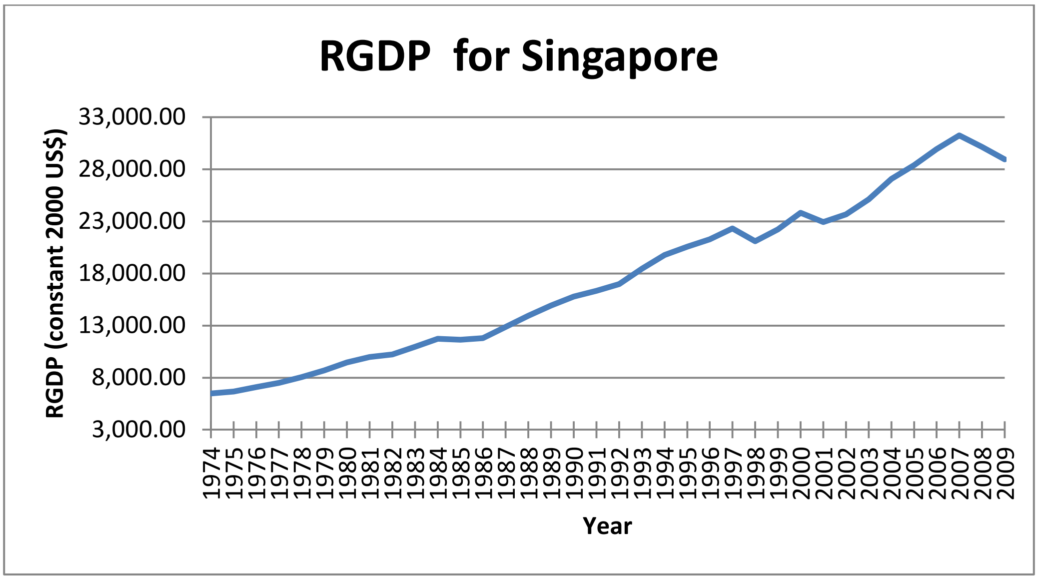
1.1.3 Singapore

Figure 1.7: CO_2 for Singapore



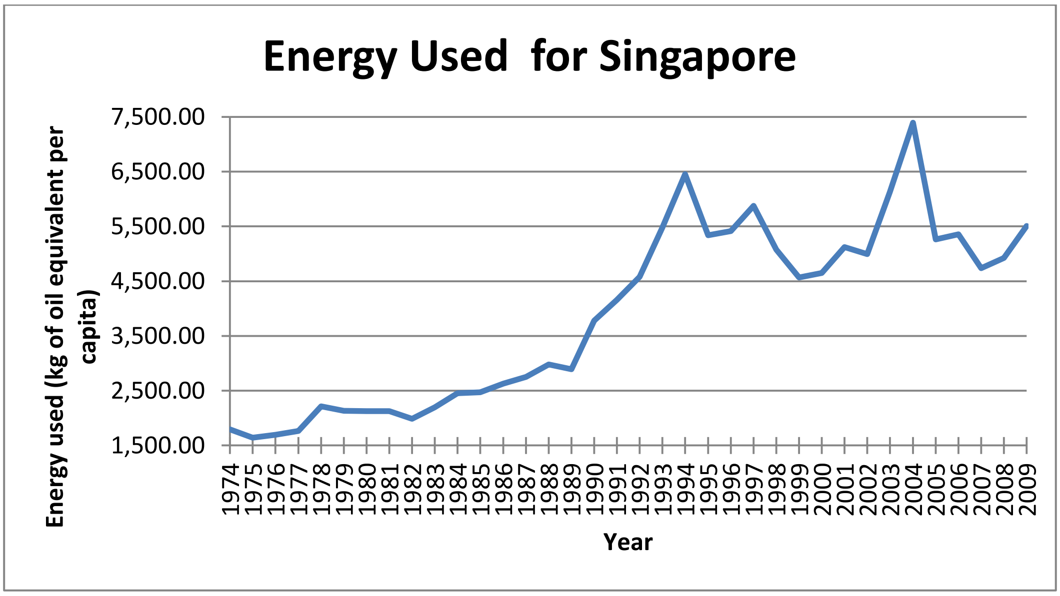
Source: Retrieved January 31, 2013 from World Bank's World Development Indicator (http://www.worldbank.org/), own illustration.

Figure 1.8: RGDP for Singapore



Source: Retrieved January 31, 2013 from World Bank's World Development Indicator (http://www.worldbank.org/), own illustration.

Figure 1.9: Energy Used for Singapore



Source: Retrieved January 31, 2013 from World Bank's World Development Indicator (http://www.worldbank.org/), own illustration.

Singapore is one of the countries that reach the status of “developed” among ASEAN countries. It is ranked as one of the most populous cities in the world (Tan, 2006). From Figure 1.7, Singapore’s CO_2 emission fluctuates over the years and there is no obvious increasing or decreasing trend. This is observed as precautions and actions were taken by the Singapore government in promoting environmental awareness among business, consumers and the community (Birchall, Stiles & Robinson, 1993). Nonetheless, Singapore was also affected by the 1997 Asian financial crisis. The country’s CO_2 emission, RGDP, and energy used were observed to have fallen too. Singapore’s CO_2 emission shows a declining trend after reaching its peak at 1994. This was due to a switch to the usage of cleaner natural gas for power generation and other government energy efficiency measures.

1.2 Problem Statement

The relationship between environmental quality and economic growth has always been an area of interest among researchers, numerous researches have been carried out to examine the relationship between environmental quality and economic growth by adding various variables that is significant in affecting the relationship between environmental quality and economic growth such as foreign trade (Jalil & Mahmud, 2009; Saboori, Sulaiman & Mohd, 2012b), electricity consumption (Lean & Smyth, 2010; Wolde-Rufael, 2006), fossil fuel consumption (Payne, 2011), and energy consumption (Acaravci & Ozturk, 2010; Ang, 2007, 2008; Apergis & Payne, 2009; Bowden & Payne, 2009). Although numerous researches had been carried out, but there are less research carry out for long-run relationship between CO_2 emission, RGDP, and energy used on ASEAN countries.

Most researches on the EKC hypothesis are carried out using panel data for a group of developing countries and developed countries (Apergis & Payne, 2009; Lee & Lee, 2009; Sanglimsuwan, 2011). However, a panel data is not able to reflect the single relationship of EKC for each country (Egli, 2004). Saboori et al. (2012b) suggested that study on individual countries is necessary to carry out in order to come out with policies that are effective and sustainable. Moreover, Egli (2004) argued the importance of the different between short-run and long-run effects on environmental quality and economic growth thus equations with explicit short term and long term dynamics are deemed to be more appropriate.

Some researchers only include economic growth and CO_2 emission as variables in examining the relationship between environmental quality and economic growth (Grubb et al., 2004; Lee & Lee, 2009; Narayan & Narayan, 2010; Sanglimsuwan, 2011). Lean and Smyth (2010) argued that this will increase the chance of suffer from omitted variable problem. Energy used is one of the important elements for economic growth as higher economic growth is associated with more energy used (Saboori et al., 2012b). Therefore it is necessary to include energy used during examining the relationship between environmental quality and economic growth.

1.3 Research Objective

1.3.1 General Objective

This study would like to examine the long-run relationship between CO_2 emission, RGDP, and energy used in ASEAN-3 countries and observe the existence of EKC in each country. Besides, this study also seeks to support and to emphasize the importance of continuous researches that are related to the environment for sustainable living.

1.3.2 Specific Objective

Specifically, this study would like:

1. To examine the long-run relationship between CO_2 emission, RGDP, and energy used in ASEAN-3 countries.
2. To examine the significance of RGDP and energy used on CO_2 emission in ASEAN-3 countries.
3. To determine the existence of EKC in ASEAN-3 countries.
4. To examine the integration between short-run and long-run.

1.4 Research Question

These are the questions that are being addressed in this study:

1. Is there a long-run relationship between CO_2 emission, RGDP, and energy used in ASEAN-3 countries?
2. What is the relationship between CO_2 emission, RGDP, and energy used in ASEAN-3 countries?
3. Does the EKC exist in ASEAN-3 countries?
4. Is there any integration between short-run and long-run?

1.5 Hypotheses of the Study

This study hypothesized that a long-run relationship exists between CO_2 emission, RGDP, and energy used. Besides, the RGDP and energy used are significant in affecting CO_2 emission and there is an existence of EKC in ASEAN-3 countries. Lastly, integration between long-run and short-run is also hypothesized.

1.6 Significance of the Study

This study attempts to study the long-run relationship between CO_2 emission, RGDP, and energy used in ASEAN-3 countries. Same researches had been done in the past, but those researches mainly focus on OECD countries and developed countries (Acaravci & Ozturk, 2010; Bernstein & Madlener, 2011; Jalil & Mahmud, 2009; Pao & Tsai, 2010). Therefore, the contribution of this study is to reconcile the lack of literatures in examining the relationship between CO_2 emission, RGDP, and energy used in ASEAN-3 countries.

This study also serves to supplement current research and awareness on the relationship between economic growth and environmental quality, so that better countermeasures and enforcements can be taken by entrusted policy makers before the effects are too deep to be amended and to enlighten the community by and large to live and develop in harmony with the environment.

1.7 Chapter Layout

This study consists of five chapters. Chapter 1 provides an introduction to the study which consists of problem statement, research objective, and research question. Chapter 2 provides the synoptic review of theoretical and empirical literature review. Chapter 3 outlines the methodology, theoretical framework, and model used in this study. Chapter 4 reports and analyses the results from the estimation of the model. Chapter 5 is the conclusion of this study which summarizes the major findings and provides policy implications and recommendations to future researchers.

1.8 Conclusion

This study will present the long-run relationship between CO_2 emission, RGDP, and energy used in ASEAN-3 countries. Besides, the existence of inverted-U curve relationship (EKC) in these countries will be identified. The following chapter, Chapter 2: Literature review will provide a series of review on the relevant theories and researches carried out in the past.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

Will the world be able to sustain development and economic growth without compromising the quality of environment, has always remained enigmatic. As such, it is not surprising that countries are very concerned on the issue of effect of economic growth on environmental quality. In general, many social and physical scientists hypothesize that higher level of income increase environmental degradation (Kaufmann, Davidsdottir, Garnham & Pauly, 1998). Conversely, many also argued that higher level of incomes reduce environmental degradation (Grossman & Krueger, 1995). Moreover, there are others who hypothesized that the relationship between economic growth and environmental quality is not fixed along a country's development path (Shafik & Bandyopadhyay, 1992). Research on this area, to investigate the relationship between economic growth and environmental quality has been carried out numerously, especially in the developed countries or a collection of countries which consist of mostly developed countries, with USA, UK, Netherland, and West Germany making a very prominent presence in such research (de Bruyn et al., 1998; Kaufmann et al., 1998). In another scenario, Acaravci and Ozturk (2010), Ang (2007), Apergis and Payne (2009, 2010), Jalil and Mahmud (2009), Lean and Smyth (2010), Lee and Lee (2009), Menyah and Wolde-Rufael (2010), Narayan and Narayan (2010), Pao and Tsai (2010), and Saboori et al. (2012a, 2012b) did research to observe the long-run relationship between environmental quality and economic growth.

Studies on the income-environment relationship and interest on the hypothesis of EKC still hold, however with more attention being paid on using

CO_2 emission as the pollutant. Acaravci and Ozturk (2010), Ang (2007), Apergis and Payne (2009, 2010), Jalil and Mahmud (2009), Lean and Smyth (2010), Lee and Lee (2009), Menyah and Wolde-Rufael (2010), Narayan and Narayan (2010), Pao and Tsai (2010), and Saboori et al. (2012a, 2012b) all used CO_2 as the dependent variable to observe the long-run relationship between environmental quality and economic growth.

This literature review seeks to review researches of such carried out in the past to provide as many insights and details on the research of economic growth and environment. This literature survey consist of the relevant theories, the independent and dependent variables used, the relationship between the environment and economic growth, the various methodologies and results from the past in this area of study.

2.1 The Fundamental Theoretical Framework - The Hypothesis of EKC

The EKC hypothesized the relationship between various indicators of environmental degradation against income per capita. In the early stages of economic growth, environmental degradation will increase until a certain level of income and then environmental improvement will subsequently occur at a higher income level. This relationship is also known as an inverted U-curve relationship, analogous to the pattern found between income inequality and economic development by Simon Kuznets (1955), who received a Nobel Prize for his work (de Bruyn et al., 1998; Selden & Song, 1994). The EKC concept only emerge in the early 1990s with Grossman and Kruger's (1991) breakthrough study of the potential impacts of North American Free Trade Agreement (NAFTA) and a background study for 1992 World Development Report by Shafik and Bandyopadhyay (1992) (Stern, 2004). However, since the inception of this relationship, there are various stands on the credibility of EKC.

2.2 The Dependent Variable - The Environmental Quality Indicators

In various empirical researches in the past to break down the relationship between economic growth and the indicators use to measure the state of the environment, the dependent variable used, is termed in their research as environmental quality (Galeotti & Lanza, 2005; Grossman & Krueger, 1995; Selden & Song, 1994), EP (de Bruyn et al., 1998; Panayotou, 2003) or environmental degradation (Ansuategi & Escapa, 2002; Kaufmann et al., 1998). The measure of the state of the environment can be taken from various dimensions as living quality is affected by the very basic of living necessities- the air, the water, the soil the climates or any aspect of the natural environment that comes in mind. Each of these dimensions may affect the economic growth in ways which has been discovered in past researches or ways that are yet to be known due to whatever limiting factors in the present.

Kaufmann et al. (1998) stated that the measure of environmental degradation variables in various studies distinctly fall into two categories; where the pollutants are measured in terms of emission or concentrations. Although, these two forms of variables can be used interchangeably, they measure different aspect of the environment. Emission shows the amount of pollutants generated by economic activities without taking the size of area into consideration. Concentrations however measure the amount of pollutants per unit volume or area but do not consider the type of activities. Therefore, neither concentrations nor emissions are the perfect measure for environmental quality. Hence, the drawbacks of these two measures will need to be recognized in the model and be interpreted accordingly.

Nonetheless, the indicators used to represent this factor take the form of various environmental pollutants. De Bruyn et al. (1998) used CO_2, Nitrogen Dioxide (NO_2) and Sulfur Dioxide (SO_2 hereafter) emission level, Grossman and Krueger (1995) used sulphur dioxide and Suspended Particulate Matter (SPM hereafter), level of dissolved oxygen in the river basin, concentrations of fecal coli form (pathogen), concentration of heavy metal (lead, cadmium, arsenic, mercury and nickel), Selden and Song (1994) used the same air pollutants studied by Grossman and Krueger (1995), along with Oxides of Nitrogen (NO_x hereafter) and Carbon Monoxide (CO hereafter). Ansuategi and Escapa (2002) used Greenhouse gases emission (GHG) as a whole; as its specific components were not mentioned and Kaufmann et al. (1998) were only interested in the atmospheric concentration of SO_2.

The choice of indicators used as the dependent variable in such studies is not explicitly mentioned by the authors. However, it is implied by Grossman and Krueger (1995) that since any dimensions of the environment may affect the economic growth of country, inclusion of more indicators might be able to provide a more comprehensive results. In another scenario, a growing number of empirical studies sought an EKC in CO_2 emissions only, as the authors stated that this pollutant is global in nature and plays a crucial role as a major determinant of greenhouse effect where greenhouse effect is the root of environmental problem (Galeotti & Lanza, 2005). For instance, CO_2 is the pollutant used in the studies of Acaravci and Ozturk (2010) for 7 European countries, Ang (2007) for France, Apergis and Payne (2009) for 5 Central American countries, Apergis and Payne (2010) for 11 Commonwealth of independent States, Jalil and Mahmud (2009) for China, Lee and Lee (2009) for 109 selected countries, Lean and Smyth (2010) for 5 ASEAN countries, Menyah and Wolde-Rufael (2010) for South Africa, Narayan and Narayan (2010) for 43 selected developing countries, Pao and Tsai (2010) for Brazil, Russia, India and China (BRIC), Saboori et al. (2012a) for Indonesia, and Saboori et al. (2012b) for Malaysia, to observe the long-run relationship between environmental quality and economic growth. Nevertheless, it was pointed out by

Grossman and Krueger (1995) that paucity of data limits the scope of the study. The pollutants (dependent variable) used as the indicator of environment in these reviewed research are the few common ones, as they are in fact even more other uncommon pollutants being explored in other researches such as deforestation, municipal waste, ammoniac nitrogen, volatile organic carbon etc.

2.3 The Independent Variables

Empirical researches in the past have used Gross Domestic Product (GDP hereafter) per capita in their research to represent the economic growth of the country (Ansuategi & Escapa, 2002; de Bruyn et al., 1998; Galeotti & Lanza, 2005; Grossman & Krueger, 1995; Kaufmann et al., 1998; Selden & Song, 1994; Stern, 2004). Most past researches agree with the EKC literature that assumes the empirical reduced-form relationship between per capita emissions and GDP can be adequately described by a parametric model, and specifically by a polynomial function of income (Galeotti & Lanza, 2005; Kaufmann et al., 1998; Selden & Song, 1994). Kaufmann et al. (1998) also included economic activity per area, iron and steel exports in nominal dollars as explanatory variables. Grossman and Krueger (1995) on the hand included a cubic function of GDP per capita as the author suggested that the cubic specification is even more flexible to describe varied relationship between pollution and GDP. However, Ansuategi and Escapa (2002) who adapted the structural model based on another author's work did not utilize GDP explicitly in their model. Complex scientific and technological assumptions are instead calibrated in his model.

In contrary with most researches, de Bruyn et al. (1998) expressed GDP per capita in terms of growth rate linearly, as the model adapted by the authors included an additional variable of intensity of use which is represented by an index of price of energy, a variable where its effect remains unravelled in the EKC hypothesis. De Bruyn et.al (1998) however did mention that a quadratic income term can be included for initial structural deterioration and subsequent improvements as in the EKC. This quadratic income term can be found in the model adopted by Acaravci and Ozturk (2010), Ang (2007), Apergis and Payne (2009, 2010), Jalil and Mahmud (2009), Pao and Tsai (2010), and Saboori et al. (2012a) together with another variable of energy consumption. Energy consumption obviously has immediate effect on the environment, as higher economic development usually calls for higher energy consumption, thus to avoid misspecification problem, its best to be tested and included in the same framework (Ang, 2007, 2008).

2.4 Income and Environment Relationship

The income-environment relationship, as specified and tested in many literatures, has always been considered in its reduced-form dynamic function that intends to capture the effect of income on the environment (Ansuategi & Escapa, 2002; de Bruyn et al., 1998; Galeotti & Lanza, 2005; Grossman & Krueger, 1995; Kaufmann et al., 1998; Selden & Song, 1994; Stern, 2004).

However, an important limitation of the reduced-form approach is that it leaves researchers who uses this approach, in oblivion, as to why the observed relationship exist. Thus, some authors argued that the reduced-form equation hides more than it can reveal and the underlying determinants of environment quality are not explicitly decomposed before this reduced-form is accepted and widely used.

Islam, Vincent, and Panayotou (1999) was the first to shed a little light on this existing relationship and identify three structural forces that affect the environment indirectly, where Panayotou (2003) and Stern (2004) later comes to agree too. These three effects are the level effect due to economic activity, composition effect, and pollution abatement effect. These three effects are explained as follow:

2.4.1 Level Effect

Income serves as the indicator for level effect from economic activity. All activities which generate income require interaction with the environment and their processes generally generate pollution and deplete resources. Hence, as the level of economic activity per capita gets higher, the higher the level of pollution is likely to be. This implies an increasing monotonic relationship between income and pollution. Income is commonly represented by the data of GDP per capita.

2.4.2 Composition Effect

Composition effect depends on another two assumed relationships, which are the income level and structure of the economy. The structure of the economy can be captured by the composition of sector output or employment in a predictable manner with the increase of income. The increase in income scale will transform the structure of an economy. This transformation subsequently reflects the intrinsic process of industrialization. This process is generally captured by the industry's share in the country's output. The share will first increase and later declines as country moves from the stages of pre-industrial, industrial and post-industrial of development. This give rise to the second assumption that, industrialization is more polluting and resource depleting than agriculture or services based industry. When combined, these two assumptions give the inverted U-curve relationship between income level and pollution.

2.4.3 Abatement Effect

The abatement effect is established upon an analogue of Engel's Law on the relationship between the demand for food and level of income. According to Engel's Law, at low income level, people are more perturb with meeting urgent material needs and worry less about the environment. Therefore, as level of income increase, they worry less on urgent material needs and appreciate environmental quality more, hence, demanding it. This effect renders the relationship between pollution and income which slopes downwards when income reached a certain level and hence the shape of an inverted-J.

The purpose of the identification of the ways in which income affect pollution is an effort to explore how the underlying determinants of environmental quality is determined, for which income level acts as a surrogate. This step may be the beginning to uncover the existence of the reduced-form relationship between environment and economic growth, which represents another branch of study in this type of research.

In short, in the reduced-form, income level actually serves as a proxy for the above three mentioned structural forces.

2.5 Methodologies Adapted in Past Research

The studies on the relationship between environment and economic growth have been approach in various methodologies. However, most have adapted their models in the reduce-form function approach (de Bruyn et al., 1998; Galeotti & Lanza, 2005; Grossman & Krueger, 1995; Kaufmann et al., 1998; Selden & Song, 1994; Stern, 2004).

De Bruyn et al. (1998) used a reduced-form function to regress the relationship between GDP per capita and gaseous emission with an additional variable of lagged income level, price of any input related factor (in the author's research which is a constructed energy price index), which when these two variables are collectively interpreted together with the constant coefficient of the econometric model is named as the intensity of use, where all variables (except the lagged income variable) were expressed in growth rates in Netherlands, UK, USA, and Western Germany, which is the first of its kind. The role of energy price is still unknown; however its possibility was also briefly mentioned by de Bruyn et al. (1998).

Selden and Song (1994) used a reduced-form function to regress the relationship between GDP per capita and SO_2, NO_x, CO, and SPM both in random effect and fixed effect. Grossman and Krueger (1995) research is an extension to the study of Selden and Song (1994) where the author also used a reduced-form function to regress the relationship between GDP per capita but with a very extensive, comprehensive collection of environmental indicators which consist of indicators for air pollution (SO_2, smoke, and heavy suspended air particles), the state of oxygen in river basins (dissolved oxygen, biological oxygen demand, chemical oxygen demand, and concentration of nitrates), pathogenic contamination of river basin (fecal coliform and total coliform), and contamination of river basins by heavy metals (concentration of lead, cadmium, arsenic, mercury, and nickel).

Galeotti and Lanza (2005) used a reduced-form function to regress the relationship between GDP per capita and CO_2 emission only using a panel data of over 100 countries and 25 years initially developed by the International Energy Agency (IEA). Kaufmann et al. (1998) used a reduced-form function to regress the relationship between GDP per capita and SO_2 emission, economic activity per area, iron, and steel exports in nominal dollars. In their study, cross sectional regression, panel data regression of fixed effect and random effect regression were both carried out.

In more recent studies, which were very much focused on examining the long-run relationship between CO_2 emissions, economic growth, energy consumption or any other variable deemed relevant based on the EKC, most had adopted the Autoregressive Distributed Lag (ARDL hereafter) methodology which was developed by Pesaran, Shin, and Smith (2001). The ARDL is commonly adopted in empirical study which has the objective to examine long-run relationship between CO_2 emissions and the real output as well as the causal relationship between the variables.

Using ARDL approach, Acaravci and Ozturk (2010), Apergis and Payne (2009, 2010), Menyah and Wolde-Rufael (2010), Pao and Tsai (2010), and Saboori et al. (2012a), all extended their studies based on the study by Ang (2007), where they examined the long-run relationship between CO_2 emission, economic growth, and energy consumption using data from different countries. Jalil and Mahmud (2009) and Saboori et al. (2012b) used similar approach, however with an additional variable of foreign trade. Lean and Smyth (2010) explicitly mentioned that his research was conducted to examine the causal relationship between CO_2 emissions, electricity consumption, and economic growth, while Narayan and Narayan (2010) solely want to test the long-run relationship between CO_2 emission and economic growth.

Lee and Lee (2009) was one exceptional study which uses another methodology called Seemingly Unrelated Regressions Augmented Dickey-Fuller (SURADF) test to conduct similar research. The author found SURADF to be much more efficient than the more-widely used ARDL.

2.6 Findings from the Past

Results from the past yielded similar conclusions in certain context but rather inconclusive in certain sense as well. It should be noted that a single prominent conclusion that holds for all researches reviewed in this literature is that the existence of the relationship between economic growth and environment seems to be undeniable although the basis of its existence is challenged theoretically and econometrically and most researches, the observed values exhibit a pattern of curve, though not the same. Grossman and Krueger (1995) and Selden and Song (1994) found a cubic N-curve. Galeotti and Lanza (1999), Islam et al. (1999), and Kaufman et al. (1998), observed a quadratic-U curve while de Bryun et al. (1998) observed a logarithm-linear relationship. The turning points for each of the indicators used are also different. Kaufmann et al. (1998) found unusually high turning points for the SO_2 level in their studies. Grossman and Kruger (1995) observed two turning points for the cubic N-curve for SO_2 out of the many indicators they observed.

The findings is inconclusive in sense that, the relationship between the environment and economic growth is so extensively observed that, different researchers use different assumptions to explain the existence of the form and functions used in the model adapted and different pollutants to represent the quality of environment, as mentioned in the previous sections. The researches which were carried out in different countries either individually or collectively may render to the ambiguity too. Thus, the results of such research do not seem to be very comparable with each other unless the direction and forms of the research are carried out in a very similar manner as its predecessors as in the case of Ansuategi and Escapa (2002), Grossman and Krueger (1995), and Selden and Song (1994).

In the context of examining the long-run relationship between the variables, the authors found that the results do provide evidence for the existence of long-run relationship between these variables (Acaravci & Ozturk, 2010; Ang, 2007; Apergis & Payne, 2009, 2010; Jalil & Mahmud, 2009; Lean & Smyth, 2010; Lee & Lee, 2009; Menyah & Wolde-Rufael, 2010; Narayan & Narayan, 2010; Pao & Tsai, 2010; Saboori et al., 2012a, 2012b). The findings were consistent with the EKC in all studies for most of the countries observed, except for Acaravci and Ozturk (2010), only Denmark and Italy supports the validity of EKC hypothesis in the author's research. Furthermore, in the study of Saboori et al. (2012a), the authors do not find the validity of EKC in their studies on Indonesia.

2.7 Conclusion

In conclusion, the findings from past researches can be summarized in one table. The following Table 2.1 summarized each important results related to each reviewed past research examining the long-run relationship between the variables. This study will be closely base on the studies by Ang (2007), Pao and Tsai (2010), and Saboori et al. (2012a). The methodology involved and justification will be discussed in Chapter 3: Methodology.

Table 2.1: Summary of Past Researches

Authors	Country	Method	Findings				
			Long-run r/s	**EKC**	**RGDP**	**RGDP^2**	**ENG**
Acaravci & Ozturk (2010)	7 European countries	ARDL	Valid	Valid in Denmark & Italy	+ve	-ve	+ve
Ang (2007)	France	ARDL	Valid	Valid	+ve	-ve	+ve
Apergis & Payne (2009)	5 Central American countries	ARDL	Valid	Valid	+ve	-ve	+ve
Apergis & Payne (2010)	11 Commonwealth of Independent States countries	ARDL	Valid	Valid	+ve	-ve	+ve
Jalil & Mahmud (2009)	China	ARDL	Valid	Valid	+ve	-ve	+ve
Lean & Smyth (2010)	5 ASEAN countries	ARDL	Valid with unidirectional causality	Valid	+ve	-ve	-

Lee & Lee (2009)	109 selected countries	Panel SURADF	Valid	Valid	+ve	-	-
Menyah & Wolde-Rufael (2010)	South Africa	ARDL	Negative long-run r/s	-	+ve	-	-ve
Narayan & Narayan (2010)	43 selected developing countries	Panel cointegration test (ARDL)	Valid in certain	Valid in certain	+ve	-	-
Pao & Tsai (2010)	BRIC	ARDL	Valid	Valid	+ve	-ve	+ve
Saboori, Bin Sulaiman & Mohd (2012a)	Indonesia	ARDL	Valid	Invalid	-ve	+ve	+ve
Saboori, Bin Sulaiman & Mohd (2012b)	Malaysia	ARDL	Valid	Valid	+ve	-ve	-

CHAPTER 3: METHODOLOGY

3.0 Introduction

This chapter will discuss on three components, the model, the data and the method. The model of this study was adopted from past researches which conducted by Ang (2007), Pao & Tsai (2010), and Saboori et al. (2012a). Using CO_2 emissions as dependent variable, this study were to examine the long-run relationship with RGDP and energy used. In addition, the square of RGDP was added into the model to determine the existence of EKC.

All the data in this study were collected from the same source, the World Bank's World Development Indicator (2013). This study's sample comprises ASEAN-3 countries, over the period of 1974-2009. This study is using time-series analysis.

Lastly, two main tests were to be run in this study: unit root test and cointegration test. Augmented Dickey-Fuller (ADF hereafter) test and Phillips-Perron (PP hereafter) test were employed to test for unit root. On the other hand, ARDL approach by Pesaran and Shin (1995) was used to test for cointegration.

3.1 Theoretical Framework

By adopting the same model used in Ang (2007), Pao and Tsai (2010), and Saboori et al. (2012a), this study follows the function below:

$$CO2 = f(RGDP, RGDP^2, ENG)$$

where, $CO2$ is the pollution indicator, CO_2 emission, $RGDP$ is income indicator, real gross domestic product and ENG is input indicator, energy used. By translating the function above into a natural log version, it as an equation as following:

$$\ln CO2_t = \beta_0 + \beta_1 TREND + \beta_2 \ln RGDP_t + \beta_3 (\ln RGDP)^2{}_t + \beta_4 \ln ENG_t + \varepsilon_t \quad (1)$$

where, $t = 1, \ldots, T$ represents time periods, β_0 and β_1 is the coefficient for intercept term and trend term respectively. The reason of including the trend variable is because the series for ASEAN-3 countries showed a strong trending pattern (see Appendices I). ε_t is the error term. β_2, β_3 and β_4 represent the coefficients of $\ln RGDP$, $(\ln RGDP)^2$, and $\ln ENG$ respectively. Under the EKC hypothesis, β_2 expected to be positive while β_3 is expected to be negative. This indicates that when an economy is growth, the country produce more CO_2 emission until a certain level, the level of CO_2 emissions starts to decline. β_3 is an indicator to examine the existence of EKC. On the other hand, the sign of β_4 is expected to be positive because higher level of energy used represents greater economic activity which result in more CO_2 emissions. In this study, the results are expected to be consistent with past research mentioned about, where $\beta_2 > 0$, $\beta_3 < 0$ and $\beta_4 > 0$.

3.2 Data

This study is conducted using secondary and quantitative data. The data covered the period of 1974-2009 for ASEAN-3 countries. The time series data are in annual basis collected from World Bank's World Development Indicator (2013). The sample size of this study is 36 for each country. Below, the Table 3.1 has summarized the description and source of the data collected:

Table 3.1: Description and Source of the Data Collected

Data	Indicator name	Unit measurement	Description
Carbon dioxide emissions	CO2	Metric tons per capita	Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring.
Real gross domestic product	RGDP	Constant 2000 US$ per capita	RGDP per capita is an adjusted measure of an inflation that reflects the sum of all goods and services produced divided by midyear population. RGDP is able to abstract from the changes in price level in order to provide a more accurate figure. It is calculated based on year 2000.

Energy used	ENG	Kg of oil equivalent per capita	Energy used refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport.

Note: All the data were converted into natural log form in the following analysis.

3.3 Econometrics Method

In this study, the ARDL approach by Pesaran and Shin (1995) was employed as a methodology to test the cointegration. Before that, a pre-test for unit root using the ADF test (Dickey & Fuller, 1979) and PP test (Phillips & Perron, 1988) was conducted.

3.3.1 Unit Root Test

Before conducting the cointegration test, researchers must determine the stationarity of the variables in the series using unit root test. According to Brooks (2008), the use of non-stationary data may cause the results to be spurious and invalid. This study conducted ADF test and PP test to determine whether the series is stationary at level, I(0) or at first difference, I(1). The null hypothesis to be tested is:

H_0: The series has unit root (non-stationary).
H_1: The series has no unit root (stationary).

The decision rule of this test is reject null hypothesis if probability value (p-value hereafter) is less than at least 10% significance level, otherwise, do not reject null hypothesis. This test aimed to reject the null hypothesis in order to conclude that the series is stationary.

3.3.2 Autoregressive Distributed Lag (ARDL) Approach

Cointegration test was developed by Engle and Granger (1987) to solve the problem of non-stationary time series data. In this study, ARDL approach (also known as bound testing), developed by Pesaran and Shin (1995) (see also Pesaran et al., 2001), was employed to determine the long-run relationship between CO_2 emissions, economic growth, and energy used. The reason of ARDL approach was employed is because it has some advantages. First, ARDL approach is applicable regardless of the independent variable's stationarity (can be stationary at either I(0) or I(1)). The dependent variable, however, must be stationary at I(1). Second, ARDL approach is more accurate in the process of generating the optimal numbers of lags (Laurenceson & Chai, 2003). Third, ARDL approach considered both short-run dynamics and long-run equilibrium (Merican, Yusop, Noor & Law, 2007). Fourth, according to Merican et al. (2007), ARDL approach is applicable for small sample size studies.

The first step of ARDL approach is to estimate the following unrestricted Error Correction Model (ECM hereafter) in order to investigate the existence of long-run relationship in Equation (1):

$$\begin{aligned}\Delta \ln CO2_t = {} & \lambda_c + \lambda_d TREND_t + \Phi_1 \ln CO2_{t-1} + \Phi_2 \ln RGDP_{t-1} \\ & + \Phi_3 (\ln RGDP)^2{}_{t-1} + \Phi_4 \ln ENG_{t-1} + \sum_{i=1}^{k} \Psi_{1,i} \Delta \ln CO2_{t-i} \\ & + \sum_{i=0}^{l} \Psi_{2,i} \Delta \ln \mathrm{RGDP}_{t-i} + \sum_{i=0}^{m} \Psi_{3,i} \Delta (\ln \mathrm{RGDP})^2{}_{t-i} \\ & + \sum_{i=0}^{n} \Psi_{4,i} \Delta \ln \mathrm{ENG}_{t-i} + \upsilon_t \end{aligned} \tag{2}$$

where λ_c is the intercept term, *TREND* is the trend term, Φ are long-run multipliers, Ψ are short-run coefficients and υ_t is error term. The null hypothesis for this hypothesis testing will be:

H_0: $\Phi_1 = \Phi_2 = \Phi_3 = \Phi_4 = 0$ (not cointegrated).
H_1: $\Phi_1 \neq 0$ or $\Phi_2 \neq 0$ or $\Phi_3 \neq 0$ or $\Phi_4 \neq 0$ (cointegrated).

To test the existence of long-run relationship, F-statistic (Wald test) is used to compare to the upper and lower bound critical values (CV hereafter) derived from the table (case IV) constructed by Narayan (2004). The reason of not using the original set of CVs constructed by Pesaran et al. (2001) is that the original set of CVs is generated for large sample size. This argument is also pointed out by Narayan (2004) and Narayan (2005). Therefore, Narayan (2004) constructed a new set of CVs applicable for small sample size study. Since this study have a relatively small sample size, it is suitable to follow the CVs constructed by Narayan (2004). The decision rule of this test is, reject null hypothesis if F-statistics is greater than upper bound CV, otherwise, do not reject the null hypothesis. If the F-statistic lies between the upper bound CV and lower bound CV, it is said to be inconclusive. In this case, this test aims to reject the null hypothesis and conclude that there is long-run relationship between the variables.

Once the long-run relationship has been identified, the next step is to choose the optimal ARDL order using suitable lag information criteria. Schwartz Bayesian Criterion (SBC hereafter) is used to choose the optimal ARDL order in this study. The ARDL (*k, l, m, n*) is generated using the following equation:

$$\ln CO2_t = \gamma_c + \gamma_d TREND + \sum_{i=1}^{k} \gamma_{1,i} \ln CO2_{t-i} + \sum_{i=0}^{l} \gamma_{2,i} \ln \mathrm{RGDP}_{t-i} + \sum_{i=0}^{m} \gamma_{3,i} (\ln \mathrm{RGDP})^2{}_{t-i} + \sum_{i=0}^{n} \gamma_{4,i} \ln \mathrm{ENG}_{t-i} + \nu_t \quad (3)$$

where *k, l, m,* and *n* are the lag lengths of each variables and ν_t is the error term. Since this study is using yearly data, a maximum lag lengths of 2 was used, where i_{max} = 2.

After the selection of optimal ARDL order based on SBC, the long-run relationship among the variables can be estimated. Once the long-run relationship has been established, restricted ECM can be expressed as Equation (4) as follow:

$$\Delta \ln CO2_t = \theta_c + \theta_d \Delta TREND + \theta_{ect} ECT_{t-1} + \sum_{i=1}^{k} \theta_{1,i} \Delta \ln CO2_{t-i} + \sum_{i=0}^{l} \theta_{2,i} \Delta \ln \mathrm{RGDP}_{t-i} + \sum_{i=0}^{m} \theta_{3,i} \Delta(\ln \mathrm{RGDP})^2{}_{t-i} + \sum_{i=0}^{n} \theta_{4,i} \Delta \ln \mathrm{ENG}_{t-i} + \nu_t \quad (4)$$

where, ECT_{t-1} is the error correction term showing the speed of adjustment of the variables adjusting back to long-run equilibrium. Short-run is said to be adjusted back when the coefficient, θ_{ect} shows a significant negative sign.

On the other hand, few diagnostic tests must have gone through for Equation (3):

3.3.2.1 Serial Correlation

This problem is most likely to occur in time series data. Classical Normal Linear Regression Model (CNLRM hereafter) assumes that there is no autocorrelation between the error term of given X's, symbolized as *cov* $(u_i, u_j | x_i, x_j)$ = E (u_i, u_j) = 0, where $i \neq j$. If the error term at period t is correlated with past error term, there is autocorrelation problem, E $(u_i, u_j) \neq 0$, where $i \neq j$. In this case, this problem causes the violation of CNLRM assumptions. This problem may cause the variance of errors to not achieving at optimal level and resulting in a biased and wrong t and F statistics. Besides, the confidence interval and probability value for independent variable will also be biased and wrong, resulting in an inefficient estimator. Breusch-Godfrey Serial Correlation Lagrange Multiplier (LM hereafter) test was used to detect autocorrelation problem. The null hypothesis (H_0) and alternative hypothesis (H_1) to be tested is:

H_0: There is no autocorrelation problem.

H_1: There is autocorrelation problem.

By computing the test statistic value for LM test = *(n-p)*R^2, and compare it to the chi-square critical value. The decision rule of this test is, if test statistic value is greater than chi-square critical value, reject the null hypothesis, otherwise, do not reject the null hypothesis. Besides, probability value (p-value hereafter) can also be use to run the test. If the p-value of LM test is less than at least 10% significance level, reject null hypothesis, otherwise, do not reject the null hypothesis. This test aimed to do not reject the null hypothesis and conclude that there is no autocorrelation problem.

3.3.2.2 Heteroscedasticity

This problem occurs when there is unequal in variance of error. CNLRM assumes that the variance of given X's, u_i , is constant or homoscedastic, symbolized as E (u_i^2) = σ^2, where i = 1, 2, …, n. When there is unequal variance of error, E (u_i^2) = σ_i^2. The violation of CNLRM will cause the same consequences as to autocorrelation problem which causes the estimator to be inefficient. The null hypothesis (H_0) and alternative hypothesis (H_1) to be tested is:

H_0: There is no heteroscedasticity problem.
H_1: There is heteroscedasticity problem.

Using p-value for the test, the decision rule for this test is, if the p-value is less than at least 10% significance level, reject the null hypothesis, otherwise, do not reject the null hypothesis. This test aimed to do not reject the null hypothesis and conclude that there is no heteroscedasticity problem.

3.3.2.3 Model Specification

This test is to ensure the estimated model is correctly specified. There are few types of model specification error: omitted a relevant independent variable, included an irrelevant independent variable, both omitted and included relevant and irrelevant independent variables, or presented the dependent and independent variables in wrong functional form. Any type of errors occurred will violate the CNLRM assumptions and may cause an invalid, biased, inconsistent, and inefficient estimated result. To detect whether the model is correctly specified, Ramsey Regression Specification Error Test (RESET hereafter) was used. The null hypothesis (H_0) and alternative hypothesis (H_1) to be tested is:

H_0: Model specification is correct.

H_1: Model specification is incorrect.

By computing the test statistic value for RESET test $= \frac{(R^2{}_{Unrestricted} - R^2{}_{Restricted})/(k_{Unrestricted} - k_{Restricted})}{(1 - R^2{}_{Restricted})/(n - k_{Restricted} - 1)}$, and compare it to the F critical value. The decision rule of this test is, if test statistic value is greater than F critical value, reject the null hypothesis, otherwise, do not reject the null hypothesis. For p-value, if the p-value for RESET tests is less than at least 10% significance level, reject the null hypothesis, otherwise, do not reject the null hypothesis. This test aimed to do not reject the null hypothesis and conclude that the model is correctly specified.

3.3.2.4 Residual Test

The residual test is performed to confirm the assumption that the model's residual are normally distributed, u_i ~ N (0, σ^2). The Jarque-Bera (JB hereafter) test was used to test the residual's normality. The null hypothesis (H_0) and alternative hypothesis (H_1) to be tested is:

H_0: The error term is normally distributed.

H_1: The error term is not normally distributed.

By computing the test statistic value for JB test = $[\frac{S^2}{6} + \frac{(K-3)^2}{24}]$, and compare it to the chi-square critical value. The decision rule of this test is, if test statistic value is greater than chi-square critical value, reject null hypothesis, otherwise, do not reject the null hypothesis. For p-value, if the p-value for JB tests is less than at least 10% significance level, reject the null hypothesis, otherwise, do not reject the null hypothesis. This test aimed to do not reject the null hypothesis and conclude that the error term is normally distributed.

3.3.2.5 Stability Test

Stability test examine whether the estimated coefficients are stable or are intervened by structural changes. As suggested by Pesaran et al. (2001), Cumulative Sum (CUSUM hereafter) and Cumulative Sum of Squares (CUSUMSQ hereafter) test (proposed by Brown, Durbin & Evans, 1975) were used to determine the stability of the estimated coefficients in this study. The null hypothesis (H_0) and alternative hypothesis (H_1) to be tested is:

H_0: The coefficients in the regression are stable.
H_1: The coefficients in the regression are not stable.

The decision rule of this test is, if the plot of CUSUM and CUSUMSQ statics falls beyond the critical bounds of 5% significance level, reject the null hypothesis, otherwise, do not reject the null hypothesis. These tests aimed to do not reject the null hypothesis and conclude that the coefficients in the regression are stable.

Two programs were used to estimate the models: EViews 6 and Microfit 4.1. Microfit 4.1 is a program developed by the author who developed ARDL approach for cointegration, Dr. Hashem Pesaran. This program is also constructed to aid the estimation of ARDL approach.

3.4 Conclusion

In summary, referring back to the past researches' findings (in Chapter 2) as well as the EKC hypothesis, this study is expected to have a consistent results with the past findings and the theory, where $\beta_2 > 0$, $\beta_3 < 0$ and $\beta_4 > 0$. This study comprises five steps in the econometrics method. First step is to test for the unit root by applying ADF test and PP test. Second step is determining the cointegration between variables by using Wald test. With a valid cointegration existed, the third step was to select the optimal ARDL order with reference to SBC. After the optimal ARDL order is selected, the fourth step was to go through few diagnostic tests: serial correlation with LM test, heteroscedasticity, model specification with Ramsey RESET test, residual test with JB test and stability test with CUSUM and CUSUMSQ. The fifth step, using the lagged Error Correction Term (ECT hereafter), the short-run was checked whether it has adjusted back to long-run equilibrium. For first and second step, EViews 6 was used to estimate the models. However, from third step onwards, Microfit 4.1 was used. The results will be interpreted in next chapter, Chapter 4: Data analysis.

CHAPTER 4: DATA ANALYSIS

4.0 Introduction

With a preparatory work on the theoretical framework, in this study, statistical results and interpretations will be presented in this chapter. ARDL model is used and the best results are interpreted. The tests carried out consist of diagnostic tests and unit root tests which intend to study the stationary of the data. All the results of the tests are obtained through Eviews 6 and MicroFit 4.1 software.

4.1 Unit Root Test

4.1.1 Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP)

In order to study the stationary characteristic for all variables in ASEAN-3 countries, unit root test – ADF test and PP test have to be carried out. In ADF test and PP test, this study has included intercept and trend and intercept. The results will be interpreted based on intercept. Based on the results, the null hypothesis of having a unit root cannot be rejected at 1% significance level for all countries' variables when the variables are defined in I(0). In the meantime, all the variables are stationary at, at least 10% significance level when the variables are defined in I(1). Thus, it can be concluded that the series for each country is integrated at order one. The results are summarized in Table 4.1.

Table 4.1: Unit Root Test Results (ADF Test and PP Test)

	ADF				PP			
	Intercept		Trend and Intercept		Intercept		Trend and Intercept	
	Level I(0)	**1st Difference I(1)**	**Level I(0)**	**1st Difference I(1)**	**Level I(0)**	**1st Difference I(1)**	**Level I(0)**	**1st Difference I(1)**
Indonesia								
ln CO2	0.6838	0.0001***	0.1159	0.0005***	0.6783	0.0001***	0.1316	0.0005***
ln RGDP	0.6664	0.0018***	0.5613	0.0082***	0.6921	0.0018***	0.7149	0.0079***
$(ln RGDP)^2$	0.7990	0.0016***	0.4913	0.0086***	0.8050	0.0015***	0.6572	0.0082***
ln ENG	0.7503	0.0000***	0.8047	0.0001***	0.7347	0.0000***	0.7955	0.0001***
Philippines								
ln CO2	0.3398	0.0038***	0.5972	0.0200**	0.4456	0.0037***	0.7342	0.0195**
ln RGDP	0.4218	0.0054***	0.9460	0.0365**	0.8268	0.0633*	0.8851	0.2775
$(ln RGDP)^2$	0.4318	0.0057***	0.9482	0.0364**	0.8368	0.0639*	0.8916	0.2791
ln ENG	0.3769	0.0090***	0.8221	0.0000***	0.3033	0.0000***	0.7991	0.0000***
Singapore								
ln CO2	0.7757	0.0001***	0.7741	0.0001***	0.7757	0.0001***	0.8339	0.0000***
ln RGDP	0.1594	0.0039***	0.9796	0.0034***	0.1562	0.0034***	0.9795	0.0044***
$(ln RGDP)^2$	0.2776	0.0029***	0.9686	0.0041***	0.2770	0.0025***	0.9646	0.0054***
ln ENG	0.6626	0.0000***	0.7469	0.0001***	0.6626	0.0000***	0.7234	0.0001***

Notes: ***** Significant at 10%; ******significant at 5%; *******significant at 1%. Equation (1) is estimated by applying ADF test and PP test.

4.2 Bound Testing

The first step of ARDL approach is to examine the existence of long-run relationship between variables for each county in Equation (2) using Ordinary Least Squares (OLS). To test the long-run relationship, Wald test has been carried out. As annual data are selected in this study, the lag lengths included in this study are one and two. According to the test results, it can be concluded that there is a cointegration among the series under consideration. The null hypothesis of no cointegration is rejected since F-statistics values of all countries are greater than upper bound CV at, at least 10% level of significance. The results of F-test for ASEAN-3 countries are shown in Table 4.2.

Table 4.2: Bounds F-tests for A Cointegration Relationship

Country	**Calculated F-statistic for different lag lengths**	
	Lag 1	**Lag 2**
Indonesia	4.1437	4.4976*
Philippines	9.4352***	3.3085
Singapore	4.4148*	1.3374

Critical Bounds of F-statistics

	1% level		5% level		10% level	
k	**I(0)**	**I(1)**	**I(0)**	**I(1)**	**I(0)**	**I(1)**
3	5.654	6.926	3.936	4.918	3.29	4.176

Notes: *****denotes rejection of the null hypothesis of no cointegration at 10% significance level. **denotes rejection of the null hypothesis of no cointegration at 5% significance level. *****denotes rejection of the null hypothesis of no cointegration at 1% significance level. *k* denotes the number of regressors. I(0) and I(1) denotes lower and upper bound CV respectively. CV derived from the table constructed by Narayan (2005): Case IV: Unrestricted intercept and restricted trend (see Appendices II).

4.3 ARDLs Selection

Once the long-run relationship is identified, next step is to select the orders of ARDL for each country according to Equation (3). The orders selection is based on the SBC. The underlying ARDL model which is Equation (3) in this study for each country does not suffer from any diagnostic problem (serial correlation, normality, heteroscedasticity, and model misspecification). The results of diagnostic tests are presented in Table 4.3. According to the results, the underlying ARDL models for ASEAN-3 countries rejected the null hypothesis of suffer from diagnostic problem at 1% significance level.

Table 4.3: Diagnostic Tests for the Underlying ARDL Models

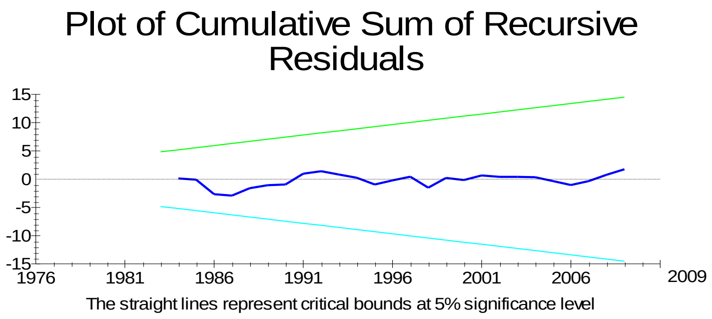
Country	Lagrange multiplier statistics			
	Serial correlation	Ramsey Reset	Normality	Heteroscedasticity
Indonesia	0.1609	0.1716	1.1902	2.5055
Philippines	0.0178	1.6017	0.2351	0.4406
Singapore	0.2974	0.7949	1.9441	0.0288

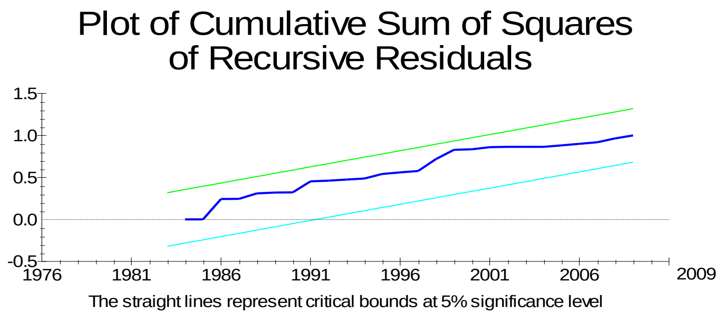
Notes: ***** Significant at 10%; ******significant at 5%; *******significant at 1%.

4.4 Stability Test

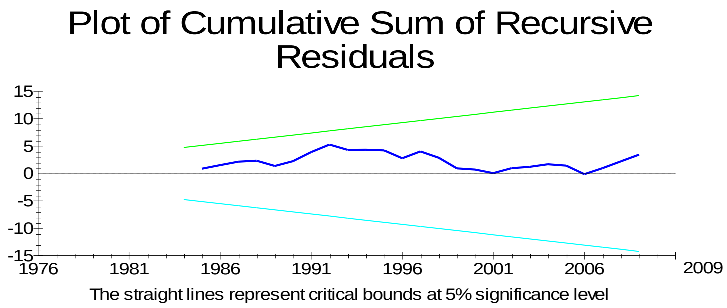
After conducted all the diagnostic tests, the stability of the estimated coefficients over the period is checked by conducting the CUSUM and CUSUMSQ test. Results are shown in Figure 4.1. By observing the CUSUM and CUSUMSQ plots, it can be concluded that the coefficients in the regression are stable and there is no structural breaks over the period since the plotted graph of CUSUM and CUSUMSQ are within the critical bounds of 5% significance level for ASEAN-3 countries.

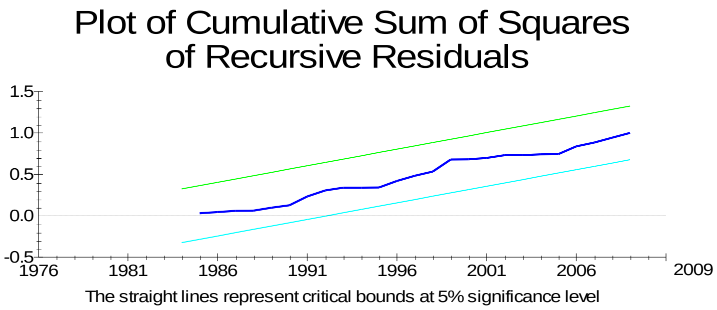
Figure 4.1: CUSUM and CUSUMSQ Plots for the Estimated Coefficient



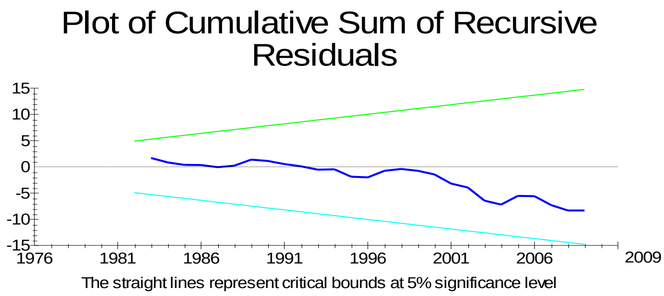


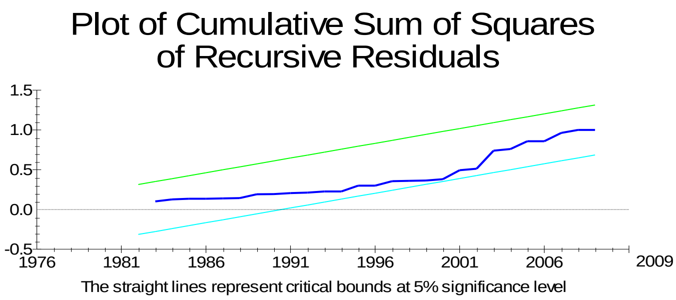
(a) Indonesia





(b) Philippines





(c) Singapore

4.5 Long-run Coefficients

The sign of each variable, estimated long-run coefficients as well as the order of ARDLs are given in Table 4.4.

4.5.1 Sign of Coefficients

As mentioned, a positive of RGDP and negative of the square of RGDP in this model signify the existence of EKC in the respective countries. However, the sign of RGDP and the square of RGDP for Indonesia and Philippines are negative and positive respectively. This indicates that there is a U-curve relationship instead of an inverted U-curve relationship. Therefore Indonesia and Philippines do not support the EKC hypothesis. It can be concluded that CO_2 emission decrease at initial level of economic growth after reaches a turning point increases with a higher level of economic growth. Although there is positive sign existed in RGDP for Singapore, the sign of the square of RGDP is positive (a U-curve relationship) instead of negative (an inverted U-curve relationship). Thus, Singapore does not support the EKC hypothesis. Meanwhile, the sign of ENG for all countries are consistent with the theory which is positive. The higher level of energy used represents greater economic activity which result in more CO_2 emissions.

4.5.2 Significance

As expected, the null hypothesis of coefficient of each independent variable is significantly rejected at 5% significance level for Indonesia. This result is consistent with the Saboori et al. (2012a) study. An increase of 1% in RGDP and energy used will cause the CO_2 emission to decrease and increase by 5.41% and 0.96% respectively. Additionally, energy used for Philippines and Singapore are also significant at, at least 10% significance level. This finding is consistent with the past researches and theory. With 1% increase in energy used, CO_2 emission will increase by 3.88% and 0.71% in Philippines and Singapore respectively. Energy used is concluded to be a statistically significant variable in explaining the CO_2 emission.

However, this study has encountered the issue of insignificance in RGDP for Philippines and Singapore. Based on the research conducted by Grubb et al. (2004), the authors stated that the fluctuation in CO_2 emission may not be necessarily associated with the fluctuation in economic growth as it has to depend on the specific political forces and the economy constructed in that country as well as the time period.

Table 4.4: Long-run Coefficient for Country-specific ARDLs

Independent Variables	**Country** *(Order of ARDL)*		
	Indonesia	**Philippines**	**Singapore**
	ARDL(1,0,1,0)	*ARDL(1,2,0,0)*	*ARDL(1,0,0,0)*
ln RGDP	-5.4128**	-284.4911	0.4233
(ln RGDP)^2	0.4379**	20.2166	0.0477
ln ENG	0.9647**	3.8828*	0.7061***
Constant	10.5074	976.2459	-9.9329
Trend	0.0002	0.0011	-0.1024***
R-Square	0.9854	0.9406	0.8348
F-stat	302.8577***	58.8256***	28.3056***

Notes: ***** Significant at 10%; ******significant at 5%; *******significant at 1%.

4.6 Error Correction Model (ECM)

Lastly, the restricted ECM is estimated to determine whether the short-run has been adjusted back to long-run equilibrium by using Equation (4). The coefficient estimates of this restricted ECM are given in Table 4.5. The lagged ECTs are significant and negative for ASEAN-3 countries. In other words, it can be concluded that short-run has been adjusted back to long-run equilibrium. The speed of adjustment towards the long-run equilibrium is 54.17% in Indonesia. Meanwhile, the speeds of adjustment of Philippines and Singapore are 65.9% and 16.22% respectively.

Table 4.5: Results of ECM for the Underlying ARDL Models

Country	Short-run Dynamics							
	ECT_{t-1}	$\Delta\ ln\ CO2_{t-1}$	$\Delta\ ln\ RGDP_t$	$\Delta\ ln\ RGDP_{t-1}$	$\Delta\ (ln\ RGDP)^2_t$	$\Delta\ ln\ ENG_t$	$\Delta Intercept$	$\Delta Trend$
Indonesia	-0.5417***	-	-2.9323***	-	0.3081***	0.5226***	5.6922*	0.0001
Philippines	-0.1622*	-	-45.1435**	0.9945***	3.2790**	0.6298**	158.3408**	-0.0002
Singapore	-0.6590***	-	0.2790	-	0.0315	0.4653***	-6.5454	-0.0675**

Notes: ***** Significant at 10%; ******significant at 5%; *******significant at 1%.

4.7 Conclusion

In short, the conclusion drawn from the estimated results in this study are shown in Table 4.4. The results for Indonesia are statistically significant and consistent with Saboori et al. (2012a). Also, the energy used is important in examining the CO_2 emission. The significant negative lagged ECTs indicated that short-run has been adjusted back to long-run equilibrium eventually for ASEAN-3 countries. Limitations and recommendations will be presenting in Chapter 5: Conclusion and recommendation.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.0 Introduction

Chapter 5 is the final chapter of this study where all of the outcomes will be concluded. The major findings from the results will be presented in this chapter. In addition, policy implications of this study as well as limitations and some possible recommendations for future researchers will be highlighted.

5.1 Summary

The objectives of this study are to examine the cointegration between dependent and independent variables and the significance of RGDP and energy used on CO_2 emission in ASEAN-3 countries. Also, determine the existence of EKC in ASEAN-3 countries and examine the integration between short-run and long-run are the objectives in this study.

Based on the results, this study has found that there is a long-run relationship in ASEAN-3 countries. Energy used is one of the significant variables in examining CO_2 emission and it is found to be significant for ASEAN-3 countries. Meanwhile, the results of Indonesia are most significant among ASEAN-3 countries and it is consistent with the past research that is conducted by Saboori et al. (2012a). Furthermore, lagged ECTs for all countries are shown to be negative and significant. In other words, the short-run has been adjusted back to long-run equilibrium. On the other hand, ASEAN-3 countries do not support the EKC hypothesis.

5.2 Policy Implications of the Study

In this study, RGDP for Indonesia has a significant effect towards CO_2 emission. Thus, it is suggested that government of Indonesia can enforce certain environment laws and regulations to address environment-violators and at the same time bring any offenders to justice. The policy may include fees or penalty on imprudent control on CO_2 emission that endanger the health of both the public and environment. For instance, government of Indonesia can impose a green tax in energy intensive industries since CO_2 emission for Indonesia grew the fastest among all ASEAN countries from 1980 to 2001 due to the development of energy intensive industries in the country (Energy Information Administration, 2004). Narayan and Narayan (2010) and Pao and Tsai (2010) also suggested a carbon emission tax in their research in energy dependent developing countries.

This study found that, energy used does have a significant effect on CO_2 emission. Thus, efforts to improve efficient energy consumption are essential. For starter, government can invest in high-tech machines or more efficient mechanisms from countries that are already advance in cleaner energy and production. At the same time, a specific team can also be set up to effectively monitor whatever mechanisms adopted. According to Shahbaz, Lean, and Shabbir (2012), government can effectively control environmental degradation by investing in new and energy-saving technology.

5.3 Limitations and Recommendations for Future Study

Using aggregated level data is one of the biggest limitations encountered in this study. Using aggregated data may lead to a biased result as selected countries may consist of many energy intensive industries and different industries have different used in energy and contribution of CO_2 emission. Energy intensive industry is identified as industry that uses huge amount of energy in their process and therefore producing high emission. For instance, beef production is considered as energy intensive industry as the tumble dryers used in the process is an energy intensive appliance. In future, researchers may determine the relationship between CO_2 emission, RGDP, and energy used in a disaggregate level subjected to availability of data. Some researchers who have carried out such research at a disaggregated level were Sari, Ewing and Soytas (2008), Ziramba (2009), Bowden and Payne (2010), and Payne (2011).

Lastly, the data of energy used in this study may consist of a combination of renewable and non-renewable sources of energy used. This may lead to a less accurate result. According to Bowden and Payne (2010), there is a positive relationship between gases emission and renewable sources of energy used while there is a negative relationship between non-renewable sources of energy used. Future researches may consider using either form of the energy used for better results, depending on objectives and data availability.

5.4 Conclusion

In conclusion, this study has achieved all the set of objectives. According to the results, RGDP for Indonesia is significant on affecting CO_2 emission. Thus, government of Indonesia can impose a green tax in energy intensive industries. Besides that, government can invest in high-tech machines or more efficient mechanisms from countries that are already advance in cleaner energy and production. Additionally, this study has encountered the issues of examining in aggregate level and combination of the renewable and non-renewable sources of energy used.

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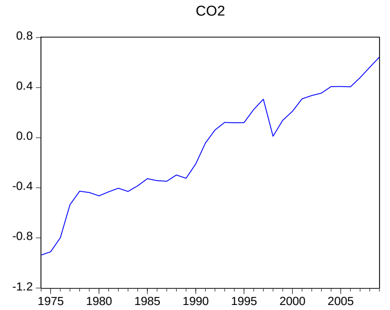
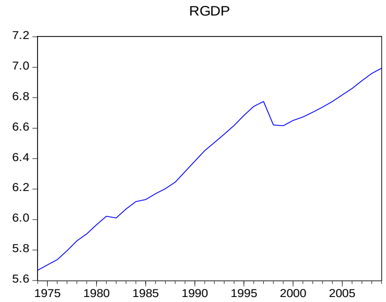
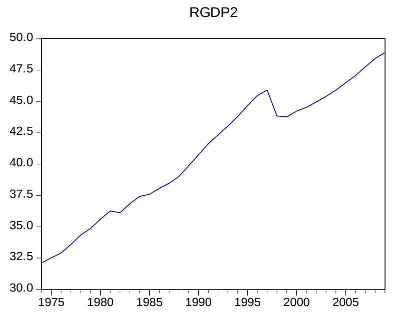
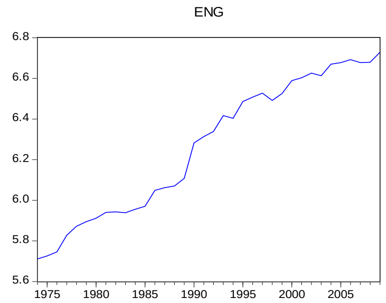
Appendices I

Indonesia Time Series

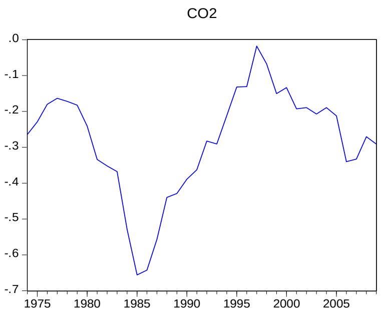


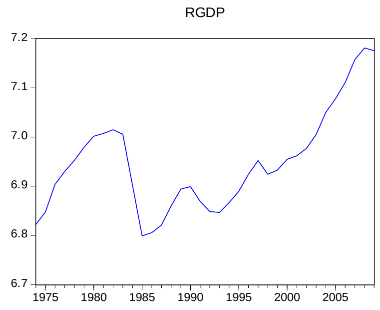


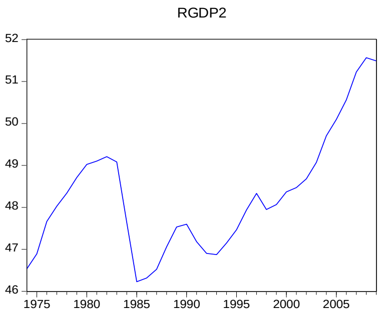


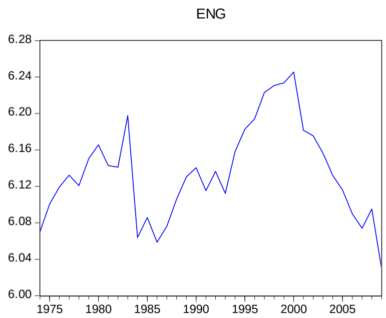


Philippines Time Series

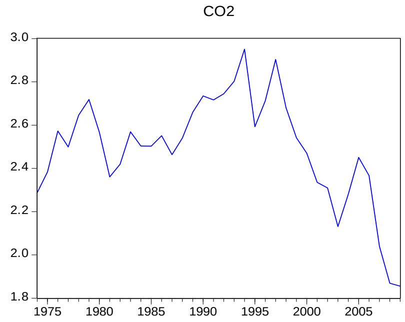


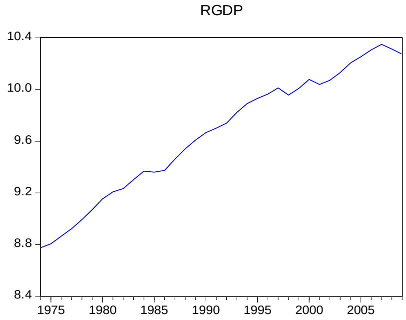


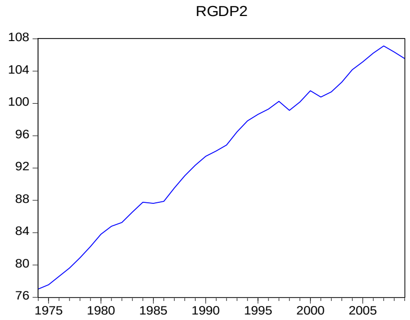


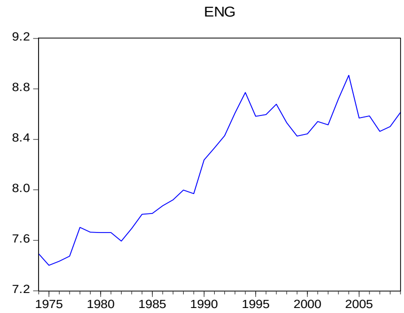


Singapore Time Series









Appendices II

Critical values for the bounds test: case IV: unrestricted intercept and restricted trend

	$k=0$		$k=1$		$k=2$		$k=3$		$k=4$		$k=5$		$k=6$		$k=7$	
n	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$	$I(0)$	$I(1)$
1 per cent																
30	10.200	10.200	7.593	8.350	6.428	7.505	5.666	6.988	5.205	6.640	4.850	6.473	4.689	6.358	4.490	6.328
35	9.975	9.975	7.477	8.213	6.328	7.408	5.654	6.926	5.147	6.617	4.849	6.511	4.629	5.698	4.489	5.064
40	9.575	9.575	7.207	7.860	5.980	6.973	5.258	6.526	4.763	6.200	4.427	5.837	4.154	5.699	3.971	5.486
45	9.555	9.555	7.133	7.820	5.878	6.870	5.150	6.280	4.628	5.865	4.251	5.596	3.998	5.463	3.829	5.313
50	9.320	9.320	7.017	7.727	5.805	6.790	5.050	6.182	4.557	5.793	4.214	5.520	3.983	5.345	3.762	5.172
55	9.300	9.300	6.893	7.537	5.678	6.578	4.990	6.018	4.455	5.615	4.111	5.329	3.870	5.171	3.643	5.021
60	9.245	9.245	6.780	7.377	5.620	6.503	4.928	5.950	4.412	5.545	4.013	5.269	3.775	5.086	3.584	4.922
65	8.960	8.960	6.707	7.360	5.545	6.453	4.848	5.842	4.347	5.552	4.020	5.263	3.758	5.040	3.557	4.902
70	8.890	8.890	6.577	7.313	5.448	6.435	4.760	5.798	4.293	5.460	3.966	5.234	3.720	5.004	3.509	4.808
75	8.905	8.905	6.613	7.253	5.505	6.298	4.808	5.786	4.300	5.377	3.984	5.153	3.728	4.954	3.511	4.789
80	6.695	6.695	5.157	5.917	4.358	5.393	3.908	5.004	3.602	4.787	3.351	4.587	3.173	4.485	3.021	4.350
5 per cent																
30	7.040	7.040	5.377	5.963	4.535	5.415	4.048	5.090	3.715	4.878	3.504	4.743	3.326	4.653	3.194	4.604
35	6.900	6.900	5.233	5.777	4.433	5.245	3.936	4.918	3.578	4.668	3.353	4.500	3.174	4.383	3.057	4.319
40	6.870	6.870	5.180	5.733	4.360	5.138	3.850	4.782	3.512	4.587	3.257	4.431	3.070	4.309	2.933	4.224
45	6.750	6.750	5.130	5.680	4.335	5.078	3.822	4.714	3.470	4.470	3.211	4.309	3.025	4.198	2.899	4.087
50	6.685	6.685	5.043	5.607	4.225	5.030	3.730	4.666	3.383	4.432	3.149	4.293	2.975	4.143	2.832	4.012
55	6.660	6.660	5.013	5.547	4.183	4.955	3.692	4.582	3.358	4.365	3.131	4.206	2.946	4.065	2.791	3.950
60	6.630	6.630	4.980	5.527	4.180	4.938	3.684	4.584	3.323	4.333	3.086	4.154	2.900	3.999	2.756	3.892
65	6.550	6.550	4.950	5.467	4.123	4.903	3.626	4.538	3.300	4.280	3.063	4.123	2.880	3.978	2.730	3.879
70	6.530	6.530	4.930	5.457	4.100	4.900	3.600	4.512	3.272	4.272	3.043	4.100	2.860	3.951	2.711	3.842
75	6.580	6.580	4.937	5.443	4.120	4.855	3.624	4.488	3.298	4.260	3.054	4.079	2.874	3.914	2.718	3.807
80	4.725	4.725	3.740	4.303	3.235	4.053	2.920	3.838	2.688	3.698	2.550	3.606	2.431	3.518	2.336	3.458
10 per cent																
30	5.785	5.785	4.427	4.957	3.770	4.535	3.378	4.274	3.097	4.118	2.907	4.010	2.781	3.941	2.681	3.887
35	5.690	5.690	4.380	4.867	3.698	4.420	3.290	4.176	3.035	3.997	2.831	3.879	2.685	3.785	2.578	3.710
40	5.680	5.680	4.343	4.823	3.663	4.378	3.264	4.094	2.985	3.918	2.781	3.813	2.634	3.719	2.517	3.650
45	5.625	5.625	4.300	4.780	3.625	4.330	3.226	4.054	2.950	3.862	2.750	3.739	2.606	3.644	2.484	3.570
50	5.570	5.570	4.230	4.740	3.573	4.288	3.174	4.004	2.905	3.822	2.703	3.697	2.550	3.609	2.440	3.523
55	5.570	5.570	4.230	4.730	3.553	4.238	3.132	3.956	2.868	3.782	2.674	3.659	2.538	3.560	2.420	3.481
60	5.555	5.555	4.203	4.693	3.540	4.235	3.130	3.968	2.852	3.773	2.653	3.637	2.510	3.519	2.392	3.444
65	5.510	5.510	4.187	4.660	3.535	4.208	3.122	3.942	2.848	3.743	2.647	3.603	2.499	3.490	2.379	3.406
70	5.530	5.530	4.173	4.647	3.505	4.198	3.098	3.920	2.832	3.738	2.631	3.589	2.485	3.473	2.363	3.394
75	5.530	5.530	4.193	4.647	3.505	4.213	3.110	3.900	2.832	3.717	2.636	3.579	2.486	3.469	2.372	3.370
80	3.870	3.870	3.113	3.610	2.713	3.453	2.474	3.312	2.303	3.220	2.180	3.154	2.088	3.103	2.017	3.052