CARBON DIOXIDE EMISSION, INSTITUTIONAL QUALITY, AND ECONOMIC PERFORMANCE: A COMPARATIVE ANALYSIS BETWEEN DEVELOPED AND DEVELOPING COUNTRIES

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ABSTRACT

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Lau Lin Sea

In recent years, the issue of global warming has received much more attention than ever since the problem is getting more and more severe. Carbon dioxide (CO_2) emission as a greenhouse gas has been blamed to be the main cause for global warming. Due to this, numerous researches have been carried out in studying the link between CO_2 emission and economic growth. Results obtained from previous studies have been inconsistent. Thus, this research serves the purpose of investigating the impact of income level on CO_2 emission further to obtain a more reliable relationship, so that the question on whether economic development can help to curb pollution would be answered. On the other hand, CO_2 emission does have an impact on GDP. Since the influence of environmental quality on income may vary in developed and developing countries depending on their stage of development, the issue is worth further examination. The study will also look into how institutional quality of a country may influence the effect of CO_2 emission on economic performance. It would help to fill the research gap since the role of institutions in explaining the link between CO_2 emission and income has yet been studied. For the purpose of this study, Generalised Method of Moments (GMM) is applied. The study considers a panel of 103 developed and developing countries over the period of 1989-2008.

The empirical results show that the existence of the inverted U-shaped relationship between income and CO_2 emissions depends on the stage of economic development of countries. Besides, it is revealed that the impact of CO_2 emissions on income also varies among income groups. The inconsistent results among income groups suggest that policy makers of different groups of countries have to design and implement varying policies in handling environmental problems while attempting to achieve high economic growth. In addition, it is found generally that institutional quality (which is measured by law and order, corruption level and institutional composite index) plays an essential role in explaining growth regardless of the stage of development. From this study, it is also discovered that CO_2 emissions contribute to a favourable impact on economic growth with the presence of proper institutional quality in all income groups. In view of the importance of institutional quality in stimulating growth without giving up on environmental quality, it is essential, therefore, for the policy makers of all income groups to take institutional quality into consideration while constructing and implementing their public policies.

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APPROVAL SHEET

This thesis entitled **"CARBON DIOXIDE EMISSION, INSTITUTIONAL QUALITY, AND ECONOMIC PERFORMANCE: A COMPARATIVE ANALYSIS BETWEEN DEVELOPED AND DEVELOPING COUNTRIES"** was prepared by LAU LIN SEA and submitted as partial fulfillment of the requirements for the Doctor of Philosophy in Economics at Universiti Tunku Abdul Rahman.

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SUBMISSION OF THESIS

It is hereby certified that LAU LIN SEA (ID No: 10ABD07323) has completed this final year thesis entitled "___CARBON DIOXIDE EMISSION, INSTITUTIONAL QUALITY, AND ECONOMIC PERFORMANCE: A COMPARATIVE ANALYSIS BETWEEN DEVELOPED AND DEVELOPING COUNTRIES" under the supervision of Prof. Dr. Choong Chee Keong (Supervisor) from the Department of Economics, Faculty of Business and Finance, and Dr Eng Yoke Kee (Co-Supervisor) from the Department of Economics, Faculty of Business and Finance.

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I hereby declare that the dissertation is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UTAR or other institutions.

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LIST OF ABBREVIATIONS

CI	Composite Index of Institutional Quality
CICO2	Interaction Term of Composite Index and CO_2 Emissions
CO2	CO_2 Emissions
CS	Capital Stock
COR	Corruption
CORCO2	Interaction Term of Corruption and CO_2 Emissions
FDI	Foreign Direct Investment
GDP	Real Gross Domestic Product Per Capita
GDP2	Square Term of Real Gross Domestic Product Per Capita
INF	Inflation
LO	Law and Order
LOCO2	Interaction Term of Law and Order and CO_2 Emissions
TO	Trade Openness
X	Exports

CHAPTER 1

INTRODUCTION

1.1 CO_2 Emissions in Developed and Developing Countries: Some Recent Issues

At present, the global climate change presents an unprecedented challenge to humankind. Since the last few decades, greenhouse gases (GHG) and their potential effects on the global climate change have received great attention from the economists and environmentalists. Based on the report of intergovernmental panel on climate change of 2007, it is estimated that the average global temperature to increase between 1.1^{o}C and 6.4^{o}C in the next century. Most importantly, an increase of merely 2^{o}C would expect to lead to a major change to natural ecosystems and a rise of sea levels that may threaten the lives of 50 percent of the world population who live in coastal areas (Lau, Tan, & Mohamed, 2009).

Kyoto Protocol 1997[1] can be considered as the first serious initiative taken by the countries in the world in attempting to cut the emissions of green house gases such as carbon dioxide (CO_2). Under Kyoto Agreement, signatories are required to reduce CO_2 emissions substantially in order to provide a possible solution to global warming. In the mean time, all signatories have to make sure that greenhouse gases emissions in 2012 will not

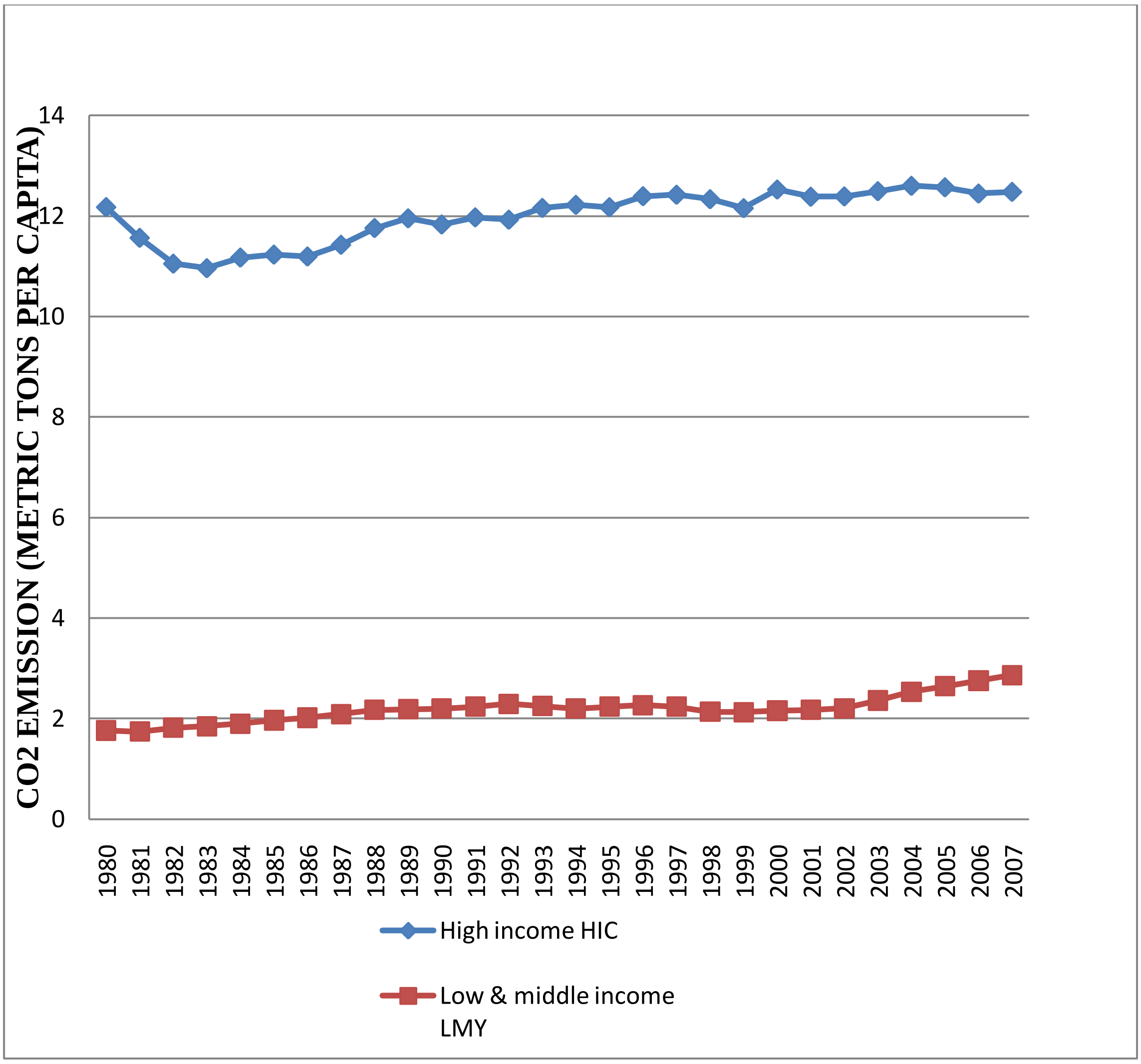
[1] Refer to United Nations Framework Convention on Climate Change (UNFCC)'s website (http://unfcc.int/) for details.

be more than the level of 1990. However, for most developing nations who are highly dependent on the energy-intensive industries for exports and economic growth, it might be very difficult for them to fulfill the requirement of reducing greenhouse gases under the Kyoto Protocol (Huang, Lin, & Yang, 2010). Further, developing countries are required to restrict the emission of GHG at the recent Copenhagen Climate Conference in 2009.

Amongst various environmental pollutants contributing to climate change, it is found that CO_2 contributes to 58.8 percent of the greenhouse gases (The World Bank, 2007). This is due to the fact that fossil fuels constitute more than 80 percent of current energy demand globally (Energy Information Administration, 2004). CO_2 is produced as a joint product with the usage of fossil fuels. This pollutant is believed to be the major global scale pollutant that can cause irreversible adverse effects on climate and subsequently the world economy. According to Soytas and Sari (2009), other than natural factors, human activities that lead to the production of CO_2 are the major cause for global warming.

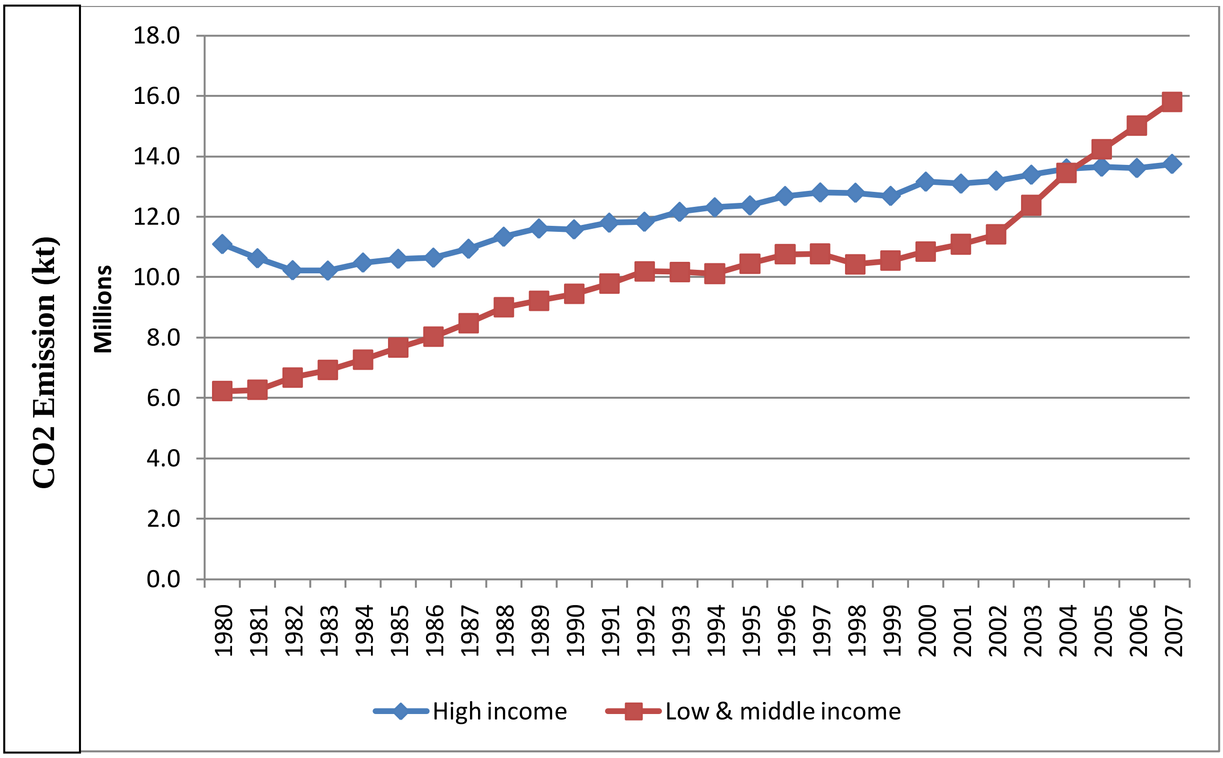
Basically, there are two types of pollutants, namely local and global pollutants. Unlike other pollutants such as sulfur dioxide (SO_2) in which their impact is more local, CO_2 emissions lead to environmental problems globally. Most importantly, the pollutant has been considered as one of the main factors contributing to the problem of global warming today (Fodha & Zaghdond, 2009). Recent research has argued that global warming may cause ozone related deaths worldwide due to higher temperatures from higher CO_2 levels in the atmosphere (Stretesky & Lynch, 2009). According to Jacobson (2008), CO_2 pollution can cause annual 7,400 to 39,000 deaths worldwide with most of these deaths occur in the developing world.

At present, the world is debating over the issue of whether developing nations should or should not be asked to bear the burden of reducing emissions in international climate negotiations. Since the industrial revolution, developed countries have been emitting huge amount of pollutants that cause global warming. Most importantly, these countries have the capacity to reduce GHG emissions and to prevent global warming. Therefore, it seems reasonable to allow the developing world to have more CO_2 emissions while requesting the developed nations to reduce their current emissions gradually. The world largest developing country—China, for example, is ranked no. 73 in the world for CO_2 emissions per capita. However, it has the world's second highest total CO_2 emissions (Haakon, Kristin & He, 2009). As indicated by Figure 1.1, CO_2 emission (metric ton) per capita in the developed countries (high income economies) are much higher as compared to developing countries (low and middle income economies). However, Figure 1.2 shows that the total CO_2 emission in developing countries has been accelerating in the last decade. Since 2004, apparently, developing countries have overshot the developed world in terms of total CO_2 emission. Thus, developing countries like China are facing the problem of how to have continuous growth while reducing emissions at the same time.



Source: World Development Indicator 2011, World Bank

Figure 1.1: CO_2 Emission Per Capita in Developed and Developing Countries



Source: World Development Indicator 2011, World Bank

Figure 1.2: Total CO_2 Emission in Developed and Developing Countries

From 2000 to 2004, the developing world is responsible for a large portion of the growth in pollution, despite low contribution of only 40 percent in total emissions. In 2004, the developing and least developed countries contributed 73 percent of the increase in total CO_2 emissions worldwide. However, the developed world caused about 60 percent of the total emissions in the same year. The developed nations had experienced a rise in total emissions within the period of 1980 to 2004 due to rapid economic growth (Raupach, 2007). In order to reduce their CO_2 emissions, the rich countries tend to shift their highly polluted carbon-intensive industries to the developing world via international trade. For example, Chinese CO_2 emissions rose by 45 percent between 2002 and 2005, in which export production contributes to half of the increase. Most importantly, 60 percent of the increased in exports was sold to developed countries. In recent years, developed countries such as US and Europe have successfully reduced greenhouse gases despite continuous economic growth. In fact, the actual amount of reduction in pollutants in these developed countries is much smaller if trade-related pollution that causes increased in CO_2 emissions in the developing countries has been taken into consideration (Yan & Yang, 2009).

When it comes to global carbon emission, it rose at the rate of more than 1 percent since 1990s annually (Lankao, Nychka, & Tribbia, 2008). Global emissions are likely to continue growing rapidly with steady global economic growth. The average annual global economic growth has been recorded at around 5 percent in recent years. It is expected that there will be continuous global growth in the near future as the role of fast growing developing countries such as China and India is getting more important in the world economy.

1.2 Problem Statement

Currently, with the deterioration of environmental problems and global warming worldwide, the issue of environment has become a major concern worldwide. Countries are particularly interested in the relationship between environmental degradation and economic development which is of great relevance to policy making. In recent years, numerous researches have attempted to construct the connection between pollution and income. Many of the empirical studies have proposed an inverse U-shaped relationship occurs between income and environmental quality in which environmental quality worsens at low levels of income, and then improves as income increases (Fodha & Zaghdiud, 2009).[2] At the early stage of economic development without structural and technological changes, as the scale of the economy increases, environmental quality declines. This is called the scale effect. Later, as economy grows to a certain level, both structural and technological changes that occur in the economy lead to a decrease in environmental degradation eventually. On the other hand, some other researchers report a monotonically increasing or decreasing or even N-shaped relationship between pollution and income.[3] Due to the inconsistency in results obtained from the previous studies, it is therefore significant to further reexamine and search for a more reliable relationship between income and environmental degradation in this study, so that the question of whether economic development can help to reduce pollution will be answered. The study of Environmental Kuznets Curve (EKC) is important to the policy makers of both developed and developing countries in designing appropriate environmental management measures that allow for better growth without giving up on environmental quality. Developing countries are particularly concerned about whether they are able to achieve green growth due to the fact that they are facing the pressures of economic growth along with increasing environmental costs.

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[2] The inverted U-shaped relationship is called the Environmental Kuznets Curve based on Simon Kuznets' Nobel-prize winning framework.

[3] See e.g., He and Richard (2009) (monotonically increasing relationship), Focacci (2003). (monotonically decreasing relationship),and Hu and Huang (2008) (N-shaped relationship).

On the other hand, however, environmental quality does have a feedback impact on economic performance according to some limited studies.[4] According to these researches, environmental quality acts as a determinant for income growth. Basically, it is found that income will tend to grow with an improvement in environmental quality particularly in developed countries. In other words, pollution affects economic performance negatively.[5] The influence of environmental quality on income level may vary in developed and developing countries depending on their stages of development. Some researchers such as Ang (2008) and Dinda (2009), for example, suggest that the impact of pollution on economic performance depends very much on the income levels of countries. In view of the importance of different income levels in affecting the link between environmental quality and economic performance, the classification of countries based on their stages of development is required. Most importantly, since there has been very little discussion about the effect of CO_2 emissions on income particularly on the use of institutions in the existing literature, the issue is worth further investigation.

In addition, the literature on finding the determinants for economic growth has been abundant. However, the empirical work is so far able to explain only partially what is behind the growth process. Thus, the study will look at how three main variables namely institutional quality, exports and FDI affect economic performance respectively. Furthermore, the role of institutions

[4] The studies include Dinda (2009), Pearson (1994) and Stern et al. (1996).
[5] See e.g. Borhan, Ahmed and Hitam (2012), Hung and Shaw (2006) and Porter and van der Linde (1995).

in influencing the impact of CO_2 emission on income level will also be discussed.

More recent researches have started to take institutional quality into consideration as a factor affecting growth in order to complement the more conventional factors such as factor accumulation and technological change found in the neoclassical and endogenous growth models. These studies have confirmed the vital role of institutions in stimulating economic growth.[6] In the mean time, various studies have been done to investigate the role of institutional quality in explaining the effect of income on the level of pollution. Generally, it is found that with good institutional quality, EKC can be flattened, indicating that the environmental cost of better economic performance can be reduced.[7] So far, however, no known research has been done to examine the role of institutional quality in affecting the impact of pollution on income level.

The issue of how institutional quality can help to explain the impact of pollution on income is worth further exploration since many countries in the world have started to consider the role of institutions in reducing CO_2 emission while attempting to sustain economic growth at the same time. For instance, Australia, the largest carbon emitter per capita in the developed world has recently passed a carbon-limiting legislation that would impose a tax on the country's 500 top polluters following the footstep of European Union and New Zealand. The legislation which has taken into effect from 1

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[6] See e.g. Aron (2000), Lee and Kim (2009) and Subramanian (2007).
[7] Refer to e.g. Leitao (2010), Panayotou (1997) and Torras and Boyce (1998).

July 2012 is set with the aim of cutting 159 million tonnes of CO_2 emission by 2020. However, the critics argue that business competitiveness and thus economic growth of the nation may be affected due to the introduction of the new legislation (Grubel, 2011).

In addition, the importance of institutions in controlling pollution can also be seen with efforts carried out by some other countries. Currently, for example, China and South Korea are working on carbon trading programs while South Africa is planning of imposing carbon caps on the nation's largest polluters.

In a nutshell, it seems that the world is moving towards the use of institutions as a means to curb pollution, therefore, it is crucial to find out the actual roles of institutional quality of a nation in explaining the effect of pollution on economic performance. Since this issue has yet been investigated, thus, the study is with the intention to fill the research gap.

The following questions are formed based on the above discussion: Does institutional quality influence the shape of EKC in different countries with different stages of economic development? What is the role of CO_2 emission and institutional quality respectively in explaining economic performance? Does the effect of pollution on income depend on the quality of institutions that seems to be so significant?

Thus, the current study intends to examine the shapes of EKC in different countries and to investigate whether institutional quality does play a role in explaining the impact of CO_2 emission on economic growth applying panel data analysis (generalised method of moments) for a panel of 103 countries (31 developed and 72 developing countries) from 1989 to 2008.

1.3 Objectives of the Study

In general, the study attempts to test the linkages between institutional quality, CO_2 emissions and income using panel data analysis (generalised method of moments) for a panel of 103 countries (31 developed and 72 developing countries) from 1989 to 2008. The countries studied can be further grouped into four distinct categories: low, lower-middle, upper-middle (developing) and high income (developed)[8] according to the World Bank Income Group Classification.

The specific objectives of the study are as follows:

i) To investigate the role of institutional quality in influencing the shapes of EKC in selected countries.

ii) To examine the effect of CO_2 emission and institutional quality respectively on different stages of economic development.

[8] The same classification is applied in literature such as Lee and Kim (2009) and Sharma (2011).

iii) To investigate the role of institutional quality plays in enhancing the relationship between CO_2 emissions and income.

1.4 Significance of the Study

According to many researchers (for example, DeCanio, 2009; Menyah & Wolde-Rufael, 2010; Reddy & Assenza, 2009), the world that we are living in could be facing reduced growth and more significant environmental disaster in the near future if nothing drastic is done to reduce global warming. According to Stern (2007), one of the most significant economic impacts of global warming is that it is expected to reduce global GDP by as much as 25 percent. Besides, the mitigation cost of greenhouse gases would take up approximately 1 percent of the global GDP.

For both developed and developing countries, it is necessary to alter the growth patterns that lead to high emissions and subsequently global warming. In fact, by applying the latest technologies, developed countries have successfully reduced their CO_2 emissions per unit of GDP and they are currently aiming to cut the overall and CO_2 emissions per capita. To the developing world, however, economic growth will still likely be their priority and the increase in CO_2 emission is inevitable. Apparently, these countries have to face a dilemma between economic growth and emissions reduction in the midst of their development.

Due to the serious effects of pollution and global warming on the world economy, therefore, it is crucial to identify possible factors that may help to cushion the negative impact of CO_2 emissions on income level. In such a case, for instance, the extent to which CO_2 emissions affect economic performance in a particular country may be influenced by the institutional quality of the country.

In recent years, many countries around the world have begun to realise the importance of utilising institutions in combating the accelerating problem of pollution and climatic change. Countries such as Finland, France, United Kingdom, New Zealand, India and recently Australia have introduced and passed legislation with the target of reducing CO_2 emission. In the case of Australia, the carbon tax imposed has the aims of providing a financial incentive for companies to curb pollution and allowing the country to reduce emission by 5 percent of year 2000 levels by 2020 (Grubel, 2011) . On the other hand, countries like China, South Korea, and South Africa are currently working on similar plans. The policy makers of these nations generally believe that institutions can help to cut emissions without having adverse effect on economic growth. However, critics suggest that institutions such as legislation may affect economic growth eventually. Due to this, the issue on the role of institutional factors in the explanation and further prediction of pollution reduction and economic growth should be stressed and further studied.

Furthermore, the other two variables namely, FDI and exports, which play crucial roles in determining growth should also be scrutinized to determine their significance in explaining growth.

In the mean time, it is vital to understand and investigate the changes of environmental quality over time with economic development. This is particularly important to those policy makers who are responsible for the formation of environmental policies. Pertaining to this, the results obtained so far from the existing empirical studies on the effects of income on CO_2 emissions have been mixed. In view of this, a check on the existence of an inverted U-shaped link between income and CO_2 emissions in both selected developed and developing countries is necessary so that the question of whether income can be the cure for environmental problem can be answered. Most importantly, the results obtained will be able to assist the policy makers of both developed and developing countries to apply feasible measures and policies to reduce CO_2 emissions without sacrificing the global economic growth.

1.5 Organisation of the Study

The study is organised into six chapters. It begins with the first chapter that deals with introduction. Chapter Two presents the contributions made by previous researches on the relationship between income and pollution. In particular, some related issues associated with the impact of income on CO_2

emission are discussed. The issues include different shapes of relationship between income and CO_2 emission such as inverted U-shaped. Besides, reasons for varying shapes and criticism on the EKC curve are also highlighted. In addition, the chapter covers a discussion on the relationship between FDI and economic growth, exports and economic growth, and institutional quality and economic growth. Furthermore, a survey of the previous studies is done to find the link between CO_2 emission, FDI and economic growth, CO_2 emission, exports and economic growth as well as CO_2 emission, institutional quality and economic growth. Specifically, the chapter contains an extensive list of authors, their methodologies and empirical models, and their findings.

Chapter Three begins with a detailed reasoning and explanation on the dependent and explanatory variables chosen. Next, the chapter presents an overview and different testing approaches of unit root tests. It also discusses the use of panel data analysis, that is, Generalised Method of Moments (GMM) to meet the objectives of the study. These econometric procedures are further analysed in the context of recent development in panel data analysis. The advantages of GMM techniques are highlighted as well. In this chapter, the rationale of countries selected and data sources is also discussed.

Chapter Four presents the empirical results for the examination of Environmental Kuznets Curve (EKC) Hypothesis with the presence of institutional quality, trade openness and foreign direct investment in various income groups based on World Bank Income Group Classification. It is found that different patterns of EKC are shown in different income groups, indicating that development stage of countries does matter in explaining the relationship between income and CO_2 emissions.

Chapter Five discusses the outcomes of the investigation for the impact of explanatory variables (exports, foreign direct investment, CO_2 emissions and institutional quality) on income in different income groups. Besides, the chapter also reports the empirical results of the role of institutional quality in explaining the impact of CO_2 emissions on income level. Institutional quality, as it is discovered, leads to a favourable relationship between CO_2 emissions and GDP in all countries irrespective of their income level.

The last chapter concludes the dissertation and also provides some important policy recommendations based on the results obtained. It is suggested that policy makers have to be cautious in designing and implementing public policies in the sense that different income groups may require different solutions to environmental problems.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter presents a survey of the economic literature on the link between economic growth and CO_2 emission in an in-depth manner. Specifically, it discusses some related issues associated with the impact of income on CO_2 emission. The issues include different patterns of relationship between income and CO_2 emission such as the inverted U- shaped Environmental Kuznets Curve (EKC) and the N-shaped EKC, reasons for varying shapes, as well as criticism on the EKC curve. Besides, it also covers some economic growth related subjects like FDI and economic growth nexus, the link between exports and economic growth, the relationship between institutional quality and economic growth, and the influence of inflation on economic growth. Furthermore, a review of the previous studies is done to find the association between CO_2 emission, FDI and economic growth, CO_2 emission, exports and economic growth as well as CO_2 emission, institutional quality and economic growth.

2.2 Environmental Pollution and Economic Development Nexus

The environmental impacts of economic development have been getting increasing attention worldwide in recent years. However, the nexus between economic performance and pollution has remained a controversial issue in the past decades.[9]

2.2.1 Early Researches

In 1970s, the Club of Rome proposed the so-called *Limits to Growth* view that shows concern about the availability of natural resources of the world (Meadows, Meadows, Randers, & Behrens, 1972). The experts from the Club of Rome suggested that the future economic development may be interrupted by the depletion of world resources and eventually lead to a steady-state economy that experiences no growth to prevent major environmental disasters in the years to come (Dinda, 2004). On the other hand, Beckerman (1992) claimed that countries would continue to enjoy growth as improvement in technologies helps to reduce dependency on natural resources. However, the argument has remained a theoretical issue since environmental data has been lacking for decades (Shafik, 1994).

Later, the empirical works by Malenbaum (1978) showed contradicting results as compared to *Limits to Growth* view. The researcher argues that the consumption ratio of certain metals to income was decreasing in rich countries

[9] Refer to Copeland and Taylor (2004), Dasgupta, Laplante, Wang, and Wheeler (2002), and Stern (2004) for important surveys on the EKC literature.

in the 1970s. Following this, a number of studies have been done on the nexus between metal used and income. It is discovered that the two variables portray an inverted U-shaped relationship. Starting from 1990s, numerous researches have been carried out concerning the link between economic growth and pollution particularly on the existence of the inverted U-shaped hypothesis as empirical data on different types of pollutants become available (Dinda, 2004). This hypothesis was initially suggested and examined by Grossman and Krueger (1991) based on North American Free Trade Agreement (NAFTA).

2.2.2 Inverted U-Shaped Relationship (Environmental Kuznets Curve)

The relationship between environmental pollution and economic growth can often be analysed by using Environmental Kuznets curve (EKC). The initial Kuznets curve explains the nexus between income and its distribution (Kuznets, 1955). In 1955, a Russian American Economist called Simon Smith Kuznets came out with a hypothesis that links income to income inequality (Stern, 2004). According to his hypothesis, economic growth may cause an increase in income inequality initially; however, income inequality will tend to diminish once income has reached a certain level in the long run. This relationship can be depicted with an inverted U-shaped Kuznets curve, following the name of the researcher.[10]

Kuznets' name is applied to the inverted-U link between economic growth and pollution because the shape is similar to Kuznets' economic

[10] The hypothesis won Kuznets the Nobel prize in 1971.

growth-income inequality nexus which is inverted U-shaped (Dinda, 2004). The earliest empirical studies on the growth and pollution nexus can be found independently in several working papers. Among these researchers, Panayotou (1993) was the first who called it as the Environmental Kuznets Curve (EKC). However, the 1992 World Development Report has popularised the Environmental Kuznets curve (EKC) hypothesis (Rezek & Rogers, 2008). The report mentioned that certain pollutants such as CO_2 emissions and urban waste will tend to increase as economy develops. However, other types of environmental indicators like insufficiency of safe drinking water would improve with better economic performance. Furthermore, the report also states that there is an inverted-U relationship between the emissions of many pollutants such as sulphuric oxides and nitric oxides with economic growth (World Bank, 1992).

An inverted U-shaped has been found in most of the studies investigating the relationship between income and pollution (Jalil & Mahmud, 2009). Among various pollutants, sulphur dioxide is one of the most widely used indicators for environmental degradation. In most of the studies, EKC hypothesis is found valid for sulphur dioxide emissions (Jalil & Mahmud, 2009). Grossman and Krueger (1993) first discover an inverted-U relationship between income and sulphur dioxide emissions. However, Dijkgraaf and Vollebergh (1998) confirm the EKC hypothesis for CO_2 in a group of developed countries. Similarly, the inverted U-shaped link between economic growth and CO_2 emissions is also found by Schmalensee, Stoker, and Judson (1998) who study two groups of nations, namely: developing countries and developed countries. The results indicate that some countries (such as U.S.) show a declining CO_2 emission as per capita income rises. However, Dijkgraaf and Vollebergh (2001) re-examine the results of Schmalensee et al. (1998) and highlight that there is a problem with the assumption of cross-country data homogeneity. The researchers further conclude that such EKC is not valid for CO_2 emissions.

In addition, Kristrom and Lungren (2003) attempt to predict the relationship between CO_2 emissions and GDP per capita based on growth-theoretic model, instead of correlating carbon emissions with GDP per capita in Sweden. The projection is done for the period 2000-2010 by using a long time series covering 1900-1999. They conclude that CO_2 emissions will tend to decrease in the future provided that nuclear power is maintained at its current level. This result is consistent with the inverted-U EKC hypothesis.

By studying different countries, with new methodologies and updated data, some more recent studies have also found similar results that support the inverted U-shaped EKC hypothesis (Martinez-Zarzoso & Bengochea-Morancho, 2004; Vollebergh & Kemfert, 2005).

Aslanidis and Xepapadeas (2005) applied a new methodological approach that is the idea of regime switching in studying the link between emission and income. The authors suggest that when a certain level of income has been reached, the economy would enter automatically into another regime with varying relationship between economic growth and pollution. Low income regime might have a direct relationship between income and emission. For those countries that have passed the threshold, a decreasing relationship is likely to be shown. For the analysis, the researchers use a set of panel data for sulphur dioxide (SO_2) and nitrogen oxide (NO_2) emissions from 48 states in U.S. between the periods 1929 to 1994. It was observed that SO_2 follows an inverted V-shaped with a high turning point. In short, SO_2 emissions smoothly peak at a relatively high level of economic development. On the other hand, NO_2 emissions would increase with economic growth at the beginning stage of development, then slows down but does not decrease with higher economic growth. This result is consistent with the outcome of the study by Stokey (1998) who found an inverted V shaped curve where dirtiest technology is only used when the income level is below the threshold. Once the threshold level is passed as income level and pollution increase, cleaner technologies will be used.

In another study, Galeotti, Lanza, and Pauli (2005) examine the relationship between economic growth and CO_2 emission applying data from the International Energy Agency (IEA) and find that the existence of EKC for CO_2 emissions depends on the source of data. It is also discovered that the inverted U-shaped pattern does appear for the rich OECD countries, while the relationship between economic growth and CO_2 emissions is positive for poor non-OECD countries.

Alternatively, Jalil and Mahmud (2009) investigate the link between income and CO_2 emissions in China between 1971 and 2005. It is suggested that EKC is valid for the pollutant. At the same time, Granger causality test shows that there is one way causality running from income to CO_2 emissions.

By employing data from 47 countries from 1980 to 2000, Lamla (2009) confirms the inverted U-shaped relationship between economic growth and three proxies of pollution that includes CO_2 emissions. However, CO_2 emissions have a high turning point in term of GDP per capita that makes its relevance becomes questionable.

Similarly, a more recent research by Zanin and Marra (2012) has found that the inverted U-shaped EKC is valid for France and Switzerland. The study was carried out using more flexible additive mix models in which the models are able to deal with nonlinear covariate effects and at the same time temporal error structure.

Likewise, Saboori, Sulaiman, and Mohd (2012) investigate the long run relationship between income and CO_2 emissions in Malaysia. Based on the results, EKC hypothesis does exist in the country both in the short and long run. By employing the same approach, Ahmed and Long (2012) attempt to study the relationship between economic growth and CO_2 emission for Pakistan using yearly data from 1971 to 2008. The results suggest that EKC hypothesis does exist in both the short run and long run in Pakistan. Further, Shahbaz, Mutascu, and Azim (2013) also found the same results for Romania using data from 1980 to 2010 after applying similar testing approach.

From the above discussion, it can be concluded that numerous existing literature has found an inverted U-shaped link between various types of pollutants and economic growth by applying different research methodologies and by studying different countries or groups of countries. This study focuses on CO_2 emissions as the type of pollutant chosen due to the fact that it has been considered as the most important pollutant leading to the problem of global warming. Further, in order to examine the validity of an inverted U-shaped EKC in different countries based on their income level, categorization of countries into four distinct groups according to World Bank Income Group Classification has been done.

2.2.1.1 Criticism on EKC Hypothesis

A number of criticisms have been raised by researchers against the EKC on theoretical and methodological grounds. According to Dinda (2004), the EKC analysis has some significant weaknesses. These weaknesses include ignorance of feedback effect, unrealistic turning points and omission of some important explanatory variables. Besides, the studies of EKC also received criticism in the sense that the result obtained depends very much on factors such as the choice of countries, time period considered, pollutant measurement and methodology applied.

EKC hypothesis is also criticised by Arrow et al. (1995) based on the fact that it assumes pollution does not lead to economic growth as income is considered as an exogenous variable. This suggests that future economic growth will persist despite pollution. In other words, sustainability is possible in economies (Dinda, 2004). In the real fact, however, a reverse relationship that runs from environmental quality to income may exist.[11] The results of some researches do show that environmental quality has an important impact on income. According to Porter and van der Linde (1995), an improvement in environmental quality can help to enhance economic growth through increased efficiency and better technological progress. Another important study by Coondoo and Dinda (2002) concludes that a unidirectional causality running from CO_2 emissions to economic growth exists in developed countries. Further, according to Dinda (2009), CO_2 emission is a determinant for economic growth among OECD countries. In contrast, for non-OECD countries, economic growth is the cause for CO_2 emissions

Furthermore, a bi-directional causal relationship between economic growth and CO_2 emissions is also possible. The change in structure of a nation from a high polluting economy into services would lead to the production of energy-efficient products as income grows. Improved efficiency leads to better economic growth. In such a case, income may be an endogenous variable. Thus, CO_2 emissions may have a feedback impact on income (Hung & Shaw, 2006). Likewise, the research by Dinda and Coondoo (2006) has proven that a bi-directional causality does exist between CO2 emissions and income for South America, North America, Asia and Oceania groupings.

[11] For example, Pearson (1994) and Stern, Common and Barbier (1996) argue that pollution does cause a feedback impact on economic growth.

Apart from that, the EKC hypothesis is also criticised for not being able to hold for some important air pollutants. Harbaugh, Levinson, and Wilson (2002) point out that the EKC hypothesis is not valid for some essential air pollutants. The EKC hypothesis is found valid merely for certain air pollutants such as SO2. This indicates that the EKC hypothesis does not exist for pollutants that lead to short- term impacts. However, for those pollutants that cause long-term effect such as CO_2, the EKC hypothesis does not seem to exist (Holtz-Eakin & Selden, 1995; Robers & Grimes, 1997). This may be due to the fact that CO_2 is a global pollutant rather than a local pollutant. The reduction of a global pollutant such as CO_2 requires a global agreement that in many occasions induce free riding behaviour. More importantly, based on the existing literature, it can be concluded that those important greenhouse gases such as CO_2 show an increasing and even “U” shaped relationship with income (Galeotti et al. 2005).

Besides, according to Caviglia-Harris, Chambers, and Kahn (2008), criticism on the studies of EKC include also the findings (particularly those based on cross-sectional data) and the policy implications. These critics have commented that the results of studies rely very much on some important factors such as countries chosen, pollutant measurement, choice of methodology, trade effects and functional form. In the mean time, various analyses indicate that the validity of EKC relation depends very much on the countries selected and time period under consideration (Grossman & Krueger, 1993; Hill & Magnani, 2002).

The determination of turning point—the income level at which pollution begins to fall, is critical in examining the EKC relation. It is important to point out that some unrealistic turning points have been found based on the existing literature. For instance, the income can be as low as US$3137 (Panayotou, 1993) at one extreme and can be as high as US$101,166 at another extreme (Stern & Common, 2001). These extreme results reflect some problems with the proposed models. The high variation in the turning points may also mean that the methodologies used and the type of pollutants studied vary among researches.

According to He and Richard (2010), the choice of functional form used does affect the level of turning point. In particular, relatively high turning points are normally found whenever log-linear models are applied.[12] The research by Holtz-Eakin and Selden (1995), for example, supports the existence of EKC for CO_2. However, the turning point in terms of per capita income obtained is beyond the scope of the sample and the researchers conclude that the marginal propensity to emit of a country tends to become zero as income rises, instead of becoming negative. The relatively high turning point between income per capita and CO_2 emission indicates that the relationship between the two variables is monotonic since most countries are impossible to achieve such a high per capita income even in the distant future.

Galeotti and Lanza (1999) did a survey on the literature and suggest that "reasonable" turning points should have the values fall within the range of

[12] For instance, by using log-linear regression models, both Holtz-Eakin and Selden (1995) and Cole (2004) found extremely high turning points at $8 million and $62,700 respectively.

USD15,000 to USD22,000 for CO_2. On the other hand, Grossman and Krueger (1995) and Selden and Song (1993) find a turning point of about $5,000 and $9,000 (in 1985 dollars) respectively for sulphur dioxide. For carbon monoxide emissions, Selden and Song (1993) obtain a peak value of about $6,000. The use of simple error component models that assume homogeneity in the pollution-income relationship across countries is another reason that leads to differences in turning points (for example, Panayotou, 1993). Following this, Unruh and Moomaw (1998) have attempted to find out the temporal patterns and discontinuous changes of income-pollution relationship in different nations using dynamic nonlinear analysis. Their results show that both historical events and external shocks of a group of developed countries affect the turning points of EKCs instead of individual income growth in these nations.

Furthermore, some researchers are arguing over the issue of the level of income that will lead to a turning point in developing countries (Miah, Masum, & Koike, 2010). The EKC is trying to indicate that economic growth is the only cure for pollution. Thus, the developing countries need to know the level of income and when it can be achieved in order for the turning point to occur. In the mean time, Lekakis (2000) points out that EKC can be misused by certain scholars to defend growth through more liberalised world market.

In addition, the EKC is also criticised for omitting some important explanatory variables in the basic relationship. Thus, a host of variables such as trade and some political economy variables ought to be included in the analysis (Galeotti & Lanza, 2004).

Besides, a more fundamental criticism raised by researchers on EKC is to do with the so called “income determinism” that believes that all countries share the same experience (Unruh & Moomaw, 1998).

Furthermore, according to Dinda (2004), the application of EKC hypothesis is feasible only for certain types of pollutants. The environmental elements such as land-use change are irreversible which are not similar to air and water pollution conceptually.

A common way of testing the EKC hypothesis utilising a quadratic or cubic regression has its own weaknesses. For instance, the EKC hypothesis is considered to be econometrically weak because the statistical properties such as serial dependence is neglected (Stern, 2004).Besides, the issue of multicollinearity is not taken into account in most the EKC studies. This has led to unrealistic turning point in EKC. In addition, another methodological problem faced is the problem of spurious regression. This problem is caused by the fact that the variables used such as real GDP per capita may be non-stationary variables. In such a case, the EKC results may not be reliable unless the model is able to fulfil the co-integration properties (Jaunky, 2011)

In addition, there are four more obvious limitations to empirically analyse EKC using reduced-form models (Kijima, Nishide, & Ohyama, 2010).

First, reduced-form relationships do not explain causal mechanism but only correlation between the variables (Cole, Rayner, & Bates, 2001). Since environmental quality may have a feedback impact on income, the application of reduced-form analyses is inappropriate in this case. Second, the choice of functional form (e.g. quadratic or cubic) tends to influence turning points of EKC in terms of type and number. Thus, different results have been obtained from different researches in association with the level of per capita income that pollution is expected to decline (Grossman & Krueger, 1995; Selden & Song, 1994; Stern et al. 1996). Third, pollution could eventually become zero or even negative which is unrealistic as income increases over time with the use of a quadratic function. Likewise, Cole, Rayner, and Bates (2001) claim that pollution will ultimately tend to become infinity as income rises. Finally, another weakness is that it has an unlikely symmetric shape in which pollution is expected to decline at the same rate as it first increased.

As a conclusion, many empirical findings have shown that EKC is only valid under certain circumstances and may not hold for some countries and for some pollutants. For example, in the case of CO_2 emissions, many recent empirical studies in fact find that EKC is valid for CO_2 emissions (Agras & Chapman, 1999; Coondoo & Dinda, 2002; Dijkgraaf & Vollebergh, 1998; Holtz-Eakin & Selden, 1995; Jalil & Mahmud, 2009; Magnani, 2001; Moomaw & Unruh, 1997; Shafik & Bandyopadyay, 1992; Tucker, 1995). However, according to Galeotti and Lanza (2004) almost all of the studies share a few common aspects. These aspects include:

(i) A reduced-form equation is used to relate CO_2 emissions with economic growth. No additional explanatory variables are included.

(ii) A panel of all individual countries in the world is utilised.

(iii) A linear or log linear in GDP is used to describe the functional relationship.

(iv) The least squares dummy variable technique is commonly used.

To further enhance the result of the relationship between CO_2 emissions and economic growth, hence, this study includes two additional variables namely foreign direct investment and trade openness into the EKC analysis. Further, the dataset of the study has been obtained from the World Development Indicators, World Bank. Most importantly, this study has considered also the feedback effect from pollution to economic growth by taking CO_2 emissions as an explanatory variable in the growth model.

2.2.3 Monotonically Increasing Relationship

An increase in national income level does not necessarily guarantee an improved environmental quality. Shafik and Banyopadhyay (1992) examine the data from 135 countries using log linear model and find a positive linear relationship between economic growth and CO_2 emissions. Similarly, Shafik (1994) and Holtz-Eakin and Selden (1995) confirm the fact that income and pollution have a monotonically increasing relationship. Further, Shafik (1994) examine the EKC for CO_2 emissions from 1960 to 1990 and find some support for the inverted U-shape EKC with a turning point which goes beyond the sample. In another study, Holtz-Eakin and Selden (1995) utilised an estimated data set from 130 countries (1951- 1986) and also confirm an inverted U-shaped EKC for CO2 emissions. However, the estimated income per capita obtained at the turning point is extremely high and unrealistic, that is, US$35,428 (in 1986 dollars) for the analysis of quadratic relationship and US$8,000,000 (in 1986 dollars) for the logarithm function relationship study. The researchers believe that income per capita and CO_2 emissions have inverted-U shaped relationship, but with a turning point that occurs at a much higher income per capita if compared to other types of pollutants.

More recently, Gangadharan and Valenzuela (2001) have done a research based on data from World Development Indicators 1998 for 51 countries, of which 22 of them are OECD countries. It was observed that income and carbon pollution show a positive linear relationship. Further, Hill and Magnani (2002) perform the largest study of CO_2 by applying data from 156 countries. Generalised least square (GLS) model is used in this study. The results indicate that inverted U-shaped EKC does not exist between income per capita and CO_2 emission. Instead, it is shown that CO_2 emissions monotonically increase with income per capita. In addition, Bertinelli and Strobl (2005) do not support the EKC hypothesis by using a non-parametric estimator. Rather, they suggested a monotonically increasing EKC for CO_2 emissions. The same outcome is obtained by Cialani (2007) who explores the relationship between income and CO_2 emissions in Italy for the period 1861-2002. The result indicates that the inverted U-shaped EKC does not seem to appear in the case of Italy. Instead, the two variables portray a monotonically increasing relationship. Similarly, Akbostanci, Turut-Asik, and Tunc (2008) argue that there is a monotonically increasing relationship between CO_2 emissions and per capita income in Turkey for the period 1968-2003 using cointegration analysis. The result shows that the EKC hypothesis does not exist and implies that pollution problem may persist even with economic growth. The authors therefore conclude that all countries need to develop policies to overcome pollution no matter what is the level of their income per capita.

Besides, Rezek and Rogers (2008) examine the link between income and CO_2 emissions between 1971 and 2000 for a number of developed nations. The results show that productivity effect outweighs the scale effect in some of the countries, which supports the EKC hypothesis. In contrast, for most countries, the productivity and composition effects are not able to offset the scale effects. Furthermore, a recent study done by He and Richard (2009) in Canada by applying semi parametric and flexible nonlinear modelling methods find very little evidence for the existence of EKC hypothesis. This analysis was carried out by utilising a set of time-series data from 1948 to 2004. It is concluded that when only income is assumed to be nonlinearly related to CO_2 emissions, the relationship between the two variables will tend to be monotonically increasing. The study also concludes that control variables such as international trade do not cause any significant influence on CO_2 emissions in Canada during the studied period. Some other recent researches done have shown similar evidences.[13]

[13] E.g. Fodha and Zaghdoud (2009), and Lee (2009).

From the above literature, it seems that the environmental Kuznets Curve does not always follow an inverted U-shaped. In fact, a number of researches (as above) have proven that a positive linear relationship may exist between CO_2 emissions and GDP, indicating that economic growth is merely the cause, but fails to act as a cure for pollution.

2.2.4 Negative Relationship

The study done by Focacci (2003a) on some developing countries indicates that the EKC hypothesis is not found in these countries. In fact, for the case of Brazil and China, it is discovered that emission intensity and income show a negative relationship. The indicator adopted to examine the link between income and pollution in this case is the intensity of CO_2 emissions from fossil-fuel burning. Similarly, a research done by Focacci (2003b) for some developed countries also indicates that as income increases, emission intensity would tend to decline.

2.2.5 N-Shaped Relationship

Some other researchers showed that GDP and CO_2 emissions follow an N-shaped relationship. According to de Bruyn, Van Der Bergh, and Opschoor (1998) and Dinda, Coondoo, and Pal (2000), the inverted U-shaped EKC may not persist over the long run. Instead, it is possible for economies to portray an N-shaped curve. The N-shaped curve indicates that initially the inverted U-shaped curve is shown, but when an income threshold is reached, the link between income and pollution turns positive.

The upward portion of N-shaped EKC eventually is due to the fact that economies find it difficult to keep up efficiency improvements with continuous increase in production. By using data covering 1960 to 1999, it is confirmed that such an N-shaped EKC does exist in Austria with the fact of a structural break in 1970s due to factors such as oil price shock (Friedl & Getzner, 2003). Likewise, Zanin and Marra (2012) also found a weak N-shaped relationship between CO_2 emissions and GDP for Austria using data for the period of 1960 to 2008.

Martinez-Zarzoso and Bengochea-Morancho (2004) find an N-shaped relationship in most of the 22 OECD countries studied, but to a great heterogeneity among them. This study is done by applying a pooled mean group estimator.

A more recent study by Hu and Huang (2008) on the link between economic development and CO_2 emissions in China results in an N-shaped relationship. The study is done by adopting the data from 31 provinces, autonomous region and municipalities of China about energy use and social economy for the period 1980 to 2005. A factor decomposition model of carbon emissions is constructed to analyse the contributions of scale effect, structural effect and technical effect on CO_2 emissions in China. The result shows that the three effects contribute a total of 19.55 percent averagely to

CO_2 emissions in China. The scale effect alone contributes 15.6 percent averagely; indicating that expansion in the scale of economy has led to a rise in CO_2 emissions. However, the structural effect is relatively stable over the years, with an average value of -0.86 percent. This suggests that structural changes in the economy cause only a minimal reduction in CO_2 emissions. The average value contributed by the technical effect is 4.65 percent, showing that this effect leads to an adverse effect on CO_2 emissions. This contradicts with the theory that says technical effect can cause a reduction in CO_2 emissions. It is because, in China, most technological progress is meant for rising labour productivity instead of concerning about environmental quality.

After examining a panel data set covering 1992 to 2001 from 58 provinces in Turkey, Akbostanci et al. (2008) find an N-shaped relationship between GDP and the emissions of SO_2 and PM_2. It can be explained by the fact that households in provinces with income lower than $2,000 use plentiful of pollution-induced items such as low quality coal. Thus, in these provinces, pollution increases while income rises. However, for provinces with income ranging from $2000 to $6000, cleaner heating alternatives such as better quality coal and natural gas are widely used. This helps to reduce pollution. In the study, there is only one province with sufficiently high income reaches the second range of the N-shape curve. The pollution rises due to the fact that this province is an industrial area.

Many researches assume that environmental indicator is a quadratic or cubic function of income. According to Kijima et al. (2010), N-shaped relation between environmental quality and income may emerge due to the use of cubic function. For example, studies by de Bruyn and Opschoor (1997) and Sengupta (1997) show such results. The N-shaped relation indicates that pollution begins to rise again after it has fallen to a certain level while income increases.

In short, other than taking the shapes of inverted-U, monotonically increasing or monotonically decreasing, it is also possible for the relationship between CO_2 emissions and economic growth to portray an N-shaped as proven by the literature above. Interestingly, this pattern of the relationship indicates that pollution would tend to increase again at very high level of income after having an inverted U-link with economic growth.

2.2.6 Researches with Mixed Results

Moomaw and Unruh (1997) try to analyse the link between CO_2 emissions and income by using data from 16 selected OECD countries. They found an inverted-U shaped pattern in majority of the countries for the period from 1974 to 1975 due to the impact of oil crisis. However, when cubic EKC model is applied to all countries, an N-shaped relationship appears.

By using a data set from 147 countries, Roberts and Grimes (1997) attempted to examine the EKC hypothesis for a period of 25 years. The studied countries were categorised into three groups based on their income per capita. It was concluded that the inverted U-shaped relationship does exist for the high income nations due to improvement in energy efficiency after oil crisis in 1970s. However, both middle income and low income countries do not show much efficiency improvement. Thus, environmental deterioration persists in these countries. The researchers' explanation is that developed countries may have transferred their dirty industries to mid- and low-income countries. The result is consistent with the pollution haven hypothesis and thus a mechanism at global level is required to overcome pollution problems internationally.

A study by Vincent (1997) on Malaysian states indicates that the link between income and some pollutants is not in line with the EKC hypothesis. In this study, income is found to be insignificantly related to the emissions of some pollutants. On the other hand, income and some other pollutants are found to have a positive relationship. Since EKC hypothesis is proven invalid in this case, therefore, the researcher suggests that better economic performance does not necessarily lead to reduction in pollution in developing countries.

In addition, by using data between 1960 and 1993, De Bruyn, Van Der Bergh and Opschoor (1998) study the validity of EKC for four developed countries and discover that the EKC generally does not exist in all of the countries.

Besides, Dinda et al. (2000) could not find the existence of EKC after investigating the link between some pollutants and economic growth from

1979 to 1990. It is discovered that SO_2 and income have a negative relationship. However, for SPM, a U-shaped relationship was found, indicating that environmental quality improves while income rises in the short run. In the long run, it deteriorates as income grows further. Bengochea-Morancho, Higon-Tamarit, and Martinez-Zarzoso (2001) employ data set from ten European Union (EU) nations covering 1981-1995 and attempt to examine the validity of EKC in these countries using panel data analysis. The result shows important disparities between those richer and poorer countries in the EU. It is found that richer countries are more polluted than those poorer countries, regardless of their income level. This indicates that there are other important explanatory variables affecting pollution besides income level.

With cointegration analysis, Perman and Stern (2003) look into the link between income and sulphur emissions by utilising a set of data from 74 countries for the period 1960 to 1990. The EKC hypothesis fails to be supported. Instead, the authors found a U-shaped nexus between sulphur emissions and GDP in many countries. They even conclude that it is problematic to say that EKC holds for sulphur emissions.

Lantz and Feng (2005) attempt to find out the important forces that cause CO_2 emissions as a result from the usage of fossil fuel use in Canada covering the period from 1970 to 2000. The results show that income is unrelated to CO_2 emissions. In other words, EKC hypothesis is rejected. Likewise, Lindmark (2002) attempts to test the existence of inverted U-shaped

EKC in Sweden using dynamic structural model. In this study, no turning point for CO_2 was found.

In addition, Soytas, Sari, and Ewing (2006) investigate the relationship between income and CO_2 emissions in the U.S. The researchers conclude that income does not Granger cause CO_2 emission in the long run. Hence, income growth by itself may not become a solution to environmental problems. This goes against the EKC hypothesis. Instead, the results show that energy consumption is the main cause for CO_2 emission in the U.S.

The research by Huang, Lee, and Wu (2007) on the relationship between GHG emissions and GDP per capita for Economies in Transition (EITs) and Annex II countries between 1993 and 2003 show different results. In the case of EITs, a quasi-L-shape curve was found, implying that pollution tends to increase with economic recovery. On the other hand, the study on Annex II countries delivers mixed results. 10 out of 21 nations studied show an increasing relationship between GHG emissions and GDP. However, another 11 countries show a declining relationship. Based on the research, EKC hypothesis is invalid in most of the countries studied (only seven show the EKC trend). The results also imply that the industrialised countries have to meet the emission target in the future with their own effort, unless they engage in international collaboration.

In addition, Narayan and Narayan (2010) investigate the validity of EKC in 43 developing countries, by looking at the values of short- and long-run income elasticities. In the case where the long-run income elasticity is smaller than the short-run income elasticity, it can be said that there would be a reduction in pollution with better growth. The main purpose of adopting this method is to overcome the problem of multicollinearity. The results of the study indicate that 15 out of 43 countries have experienced a decline in CO_2 emission over time with a rise in income as the short-run income elasticity outweighs the long-run elasticity. Most importantly, only 6 out of the 15 countries show negative income elasticity where the long run income has caused a reduction in CO_2 emissions.

Following Narayan and Narayan (2010), Jaunky (2011) intends to test the relationship between income and CO_2 emissions in 36 developed countries between 1980 and 2005. The results show that in both the short run and long run, a unidirectional causality runs from GDP to CO_2 emissions. However, pollution does not Granger- cause income in the long run based on the VECM causality test. The results also reveal that CO_2 emissions tend to stabilise over the long run in high-income countries.

On top of that, Niu, Ding, Niu, Li, and Luo (2011) found that a causality is running from GDP to CO_2 emissions unidirectionally in the long run from eight Asia-Pacific countries for the period between 1971 and 2005 using panel data. The finding indicates that a rise in per capita income will lead to an increase in CO_2 emissions in the developed world. On the other hand, the authors discover a unidirectional causality from CO_2 emissions to GDP for developing countries in the long run. The result implies that developing countries need to increase CO_2 emissions in order to obtain higher economic growth. This is in line with the study by Dinda and Coondoo (2006) who conclude that in the absence of cleaner technology, the developing countries need to give up their economic growth aspirations; only then emissions can be reduced.

2.2.6.1 Does type of pollutant matter for the shape of EKC?

Miah, Masum, and Koike (2010) conduct a review of the existing literature on EKC hypothesis for three different types of pollutants, namely CO_2, SOx and NOx for the period between August 2008 and August 2009. These pollutants are chosen due to the fact that they are the main culprits that cause global warming. In the study, the researchers attempt to compare the EKC of Bangladesh with other developing nations. The results of the study show that in most cases CO_2 demonstrates a monotonically increasing link with economic growth with non-existence of turning point. This phenomenon can be explained by the fact that CO_2 is a global pollutant where it cannot be internalised within a country if compared to those local pollutants. Free riding behaviour is common among nations since they “share” the social cost of pollution. Therefore, the positive relationship between GDP and CO_2 emissions would last for a long period of time even with very high income level. However, according to the observation, SOx (oxides of sulphur) portrays an inverted U-shape curve under most situations. In addition, developing countries are found to have turning point at lower income level as compared to developed countries. This may be due to worldwide reduction in the use of sulphur under the Sulphur Protocol of 1985. For NOx (oxides of nitrogen), only studies in OECD (developed) countries produce an inverted U-shape EKC. On the other hand, developing countries are facing basically an upward straight line for income and NOx emission. The results obtained are consistent with the findings of some previous researches.

For instance, Lieb (2004) reviews works by 17 researchers and point out that 13 of these researches show an upward straight line between income and CO_2 emission. Thus, it can be concluded that EKC for CO_2 is a monotonous straight line under most occasions. In other words, it can be said that economic growth does not bring about a better environment in the case of CO_2. Talukdar and Meisner (2001) also explain that the monotonic relationship between income and CO_2 emission is due to the fact that CO_2 is a global pollutant. Because of this, very few efforts have been taken so far by countries to reduce CO_2 emissions. In a much earlier research done by Shafik and Bandhopadhyay (1992), similar argument has been made. They point out that due to greater local benefits of abatement, local pollutants decline as income rises. On the other hand, the emissions of global pollutants such as CO_2 continue to rise.

To conclude, it seems that the inverted-U relationship is less possible in the case CO_2 emission from the theoretical point of view because it is a global pollutant. However, empirical studies have proven that the evidence of EKC hypothesis for CO_2 emissions is so far mixed. Different patterns of relationship have been shown. Despite some researches find a linear correlation between CO_2 emission and income, others claim that the relationship follows an inverted U- shaped with unrealistic turning points. Besides, some other studies discover an N-shaped relationship between the two variables.

2.2.6.2 Reasons for Varying Relationships

Some researchers such as Grossman and Krueger (1995) and Selden and Song (1993) have pointed out that the growth and pollution nexus, whether positive or negative, varies from country to country, depending on resource endowment, composition of economic activities and social customs of a particular country. In short, each country has its own EKC. This view is supported by Hill and Magnani (2002) who also argue that the EKC pattern depends very much on the choice of pollutant, sample of countries and time period.

Similarly, according to Hettige, Lucas, and Wheeler (1992), the characteristics of different pollutants can influence the net impact of economic development on environmental quality. For example, an inverted-U EKC does exist for some important air pollutants like suspended particulate matter and sulphur dioxides. In addition, Selden and Song (1994) also find the same results in relations to EKC for some air pollutants like SO_2. However, Shafik and Bandyopadhyay (1992) point out that CO_2 emissions have a positive relationship with GDP.

Wagner (2008) in his study, however, argues that the relationship between GDP and emissions may turn out to be a monotonous, a U-shaped, an inverted U-shaped or any other shapes depending on the relative magnitudes of the scale, composition and technique effects. In relation to this, Andreoni and Levinson (2001) explain that pattern of the relationship relies on the returns to scale of the abatement technology applied. According to Jones and Manueli (2001), endogenous policy choices such as voting about emissions charges can cause a non-monotonous relationship between income and emissions. The study also points out that income-emissions relationship differs among countries because political institutions are not the same in these countries.

Based on the discussion above, it can be said that the shape of EKC depends very much on various critical factors such as type of pollutant considered, size of scale, composition and technique effects and the quality of institutions. Thus, for the purpose of this study, the most vital pollutant that causes climatic change, that is CO_2 emission has been chosen. Further, in order to see how the varying magnitude of the scale, composition and technique effects in countries with different income levels influences the shape of EKC, four distinct income groups namely, high income, upper middle income, lower middle income and low income have been formed. Most importantly, institutional quality FDI and trade openness have been considered in this study to provide a better insight to the relationship between CO_2 emissions and economic growth.

2.3 The Relationship between Foreign Direct Investment (FDI) and Economic Growth

There are basically two models that can be used to explain how foreign direct investment (FDI) can stimulate economic growth. First, Solow-type standard neoclassical growth models propose that FDI helps to increase the capital stock and hence economic growth by financing capital formation. However, FDI only leads to short run effect on growth in this case due to diminishing returns to capital (Brems, 1970). On the other hand, endogenous growth models suggest that FDI is able to enhance growth in the long run since it encourages capital accumulation and knowledge spillovers. In this case, FDI- induced technological spillovers are believed to outweigh the impact of diminishing returns to capital (De Mello, 1997).

A vast number of researches have been done to study the relationship between FDI and economic growth for several decades. However, mixed results of these studies indicate that the relationship between the two variables remains controversial. Some studies report a positive effect while others show a negative effect of FDI on economic growth (Blomstrom, Marcellino, & Osbat, 2005; Buckley, Wang, & Clegg, 2007; Meyer, 2004). To conclude, in most cases, studies that involved solely developed economies produce a significantly positive relationship between FDI and economic growth. For instance, studies by Barry and Bradley (1997) on Ireland, Liu, Siler, Wang, and Wei (2000) on the United Kingdom and Schneider (2005) on some rich nations have proven the positive relationship.

On the other hand, researches done on developing countries show mixed results with some showing a direct link between FDI and growth (Hansen, & Rand, 2006; Lim, 2001) while others prove no significant impact of FDI on productivity in the host countries (Akinlo, 2004; Schneider, 2005). Moreover, a more recent study by Ran, Voon, and Li (2007) using a panel data from China shows the same result. The researchers conclude that FDI may not necessarily contribute to an overall increase in output growth. Instead, only those local industries with foreign participation gain while the rest lose. Similarly, by applying cointegration test, Mah (2010) examines the causal relationship between FDI inflows and economic growth in China and finds that FDI inflows do not lead to economic growth. Instead, economic growth is revealed to cause the FDI inflows.

However, a study by Yao and Wei (2006) using China as an example for newly industrialising economies suggests that FDI contributes positively to growth in these countries. With FDI, productive efficiency of local firms in China has been increased and hence the production frontier has been shifted towards the level of developed countries. Similarly, a recent study by Whalley and Xin (2010) for China shows that FDI has been the main stimulator of Chinese economic growth in the past few years. Based on the results obtained, the reseachers conclude that the GDP growth rate of China would be around 3.4 percentage points lower if there were no FDI inflows in the country. Furthermore, Herzer, Klasen, and Nowak-Lehmann (2007) examine the validity of FDI-led growth hypothesis using a sample of 28 developing countries and find that FDI does not play a vital role in explaining both short-run and long-run growth in most of the countries. Indeed, only four out the 28 countries studied show a positive role of FDI on long-run growth.

Some other studies even obtain a negative relationship between FDI and economic growth for the developing economies. For example, Bornschier and Chase-Dunn (1985) argue that FDI encourages the formation of monopolies in the host countries that may lead to what they call as "underutilization of productive forces". Thus, FDI tends to have a negative impact on growth. Likewise, a study by Borensztein, De Gregorio, and Lee (1998) for 69 developing countries suggests a negative effect of FDI on economic growth.

Several reasons can be put forward to explain the negative or insignificant results. One of the most important reasons is that the domestic firms are unable to compete with foreign firms which may cause a reduction in local productivity. This is due to the fact that foreign firms have much lower costs of production, which enable them to steal demand from local firms (Aitken & Harrison, 1999). Furthermore, the positive knowledge spillovers may not necessarily occur due to three reasons. First, the foreign firms may not want to share their knowledge (Gorg & Greenaway, 2004). Moreover, local firms with obsolete technologies and unskilled labours may not be able to learn from foreign companies. Lastly, underdeveloped financial markets in the host countries may hinder local firms from having the ability to invest in absorbing foreign technologies (Herzer, Klasen, & Nowak-Lehmann, 2007).

For example, Aitken and Harrison (1999) suggest that knowledge spillovers do not occur in the case of Venezuela by applying a set of panel data.

In general, however, FDI tends to have a positive impact on economic growth in the developing world despite of the potential negative impacts. The degree to which FDI affects growth, in fact, is subject to the economic and political factors of the host nations. These factors include degree of trade openness, human capital base, level of development of local financial markets, level of technological development and so forth (Herzer, Klasen, & Nowak-Lehmann, 2007). Similarly, Akinlo (2004) argues that productivity of the foreign capital relies on some initial economic and social factors of the host countries including introduction of advanced technology and trade openness.

For instance, based on data from 46 developing nations, Balasubramanyam, Salisu, and Sapsford (1996) discover that trade openness is a vital factor determining how strong FDI can influence economic growth. They suggest that a more open economy can attract more FDI if compared to a less open economy. In addition, the results of the study show that FDI is a better tool in stimulating growth than domestic growth due to technology spillovers. Likewise, a survey by Borensztein et al. (1998) on 69 developing countries finds that the degree to which FDI can affect growth relies on the level of education in the host countries. Furthermore, Alfaro, Chanda, Kalmli-Ozean, and Sayek (2004) use data from developing and developed countries to study the relationship between FDI, financial markets and economic growth. The results indicate that FDI is an important determinant for growth with the condition that the local financial markets must have reached certain level of development. By examining U.S multinational companies as a channel of international technology transfer, Xu (2000) confirms the importance of human capital in explaining a positive FDI-growth nexus. Using data from 40 countries for the period 1966 to 1994, the author finds that technology transfer given by U.S multinational companies through FDI leads to higher growth only in developed but not in developing countries. This is due to the fact that developing countries do not have enough human capital that is able to absorb the latest technologies transferred.

Besides, recent researches also highlight the importance of institutions such as property rights, human rights, rule of law, and level of democracy (Easterly, 2005) in ensuring a positive FDI-growth relationship. It is argued that high institutional quality in the host country may contribute to reduced investment costs and increase spillovers from FDI (Bengoa & Sanchez-Robles, 2005).

Another significant conclusion that can be drawn from the existing literature is that the impact of FDI varies from sector to sector in the economy. In general, manufacturing sector receives the most benefits from FDI if compared to other sectors. As noted by Chakraborty and Nunnenkamp (2007), FDI contributes to different growth effects in different sectors in India. They find that FDI and output are mutually reinforcing only in the manufacturing sector over the long-run. In contrast, there is little evidence that a causal relationship exists between FDI and output in the primary sector. Similarly, the study shows that FDI does not contribute much to output growth in the services sector. Likewise, Akinlo (2004) attempts to find out whether FDI contributes to growth in extractive sector (such as oil subsector) as many empirical studies have shown for manufacturing sector. The results indicate that extractive FDI leads to growth only after a considerable lag in Nigeria. Most importantly, the author finds that FDI in the extractive sector does not lead to much growth if compared to the FDI in the manufacturing sector.

From the above discussion, it seems that the link between FDI and growth remains highly controversial. The impact of FDI on growth can be negative, positive or insignificant depending on the country studied as well as on the local factors of the host country.

2.4 Exports and Economic Growth Nexus

Hundreds of researches have been conducted to study the exports-growth nexus in the last two decades in different nations. According to Giles and Williamson (2000), the causal link between economic growth and exports can be grouped into four categories after surveying more than 150 related papers. First of all, a unidirectional causal relationship can go from exports to growth, and the reverse (unidirectional causality from growth to exports) is also possible. Furthermore, bidirectional causality between the two variables is discovered too in the existing literature. Another possibility is another factor can be the determinant of both. In other words, there is no clear agreement on whether exports cause growth or growth stimulates exports. However, majority of the early studies using cross-section data support the former.

Based on the export-led growth hypothesis, exports lead to economic growth (Balassa, 1978; Edwards, 1998). There are a few reasons that can explain why export activities and trade openness are key factors for economic growth. For instance, export expansion stimulates the production of more goods for exports. Due to this, firms will be able to engage in specialisation that makes the exploitation of economies of scale and country's comparative advantages possible. Moreover, stiff foreign market competition encourages technological innovation in the domestic country. In addition, the foreign exchange earned from exports enables countries to raise imports of capital goods as well as technologies and in turn further increases production and income.

For example, Qiaoyu (1998) finds that other than fixed investment, merchandise exports are the major determinant for economic growth in China from 1980s to 1990s. Awokuse (2006) studies how do export and import affect growth in three transitional economies (Bulgaria, Czech Republic, and Poland) and found that exports stimulate economic growth. Apart from that, using data for the period from 1971 to2006, Lean and Smyth (2009) investigate the causality among five variables, namely aggregate output, electricity consumption, exports, labour and capital in Malaysia. The results indicate that exports Granger cause economic growth that is consistent with the export-led-growth hypothesis. More recently, Pistoresi and Rinaldi (2012) found evidence for export-led growth hypothesis in Italy for the period of 1863-2004 by employing cointegration analysis and casaulity tests.

However, the arguments for exports-led-growth hypothesis has been criticised by a group of researchers who believe in inward oriented trade policies instead of outward oriented trade policies. They argue that exports cannot lead to growth due to a few reasons. The reasons given include deteriorating terms of trade and inefficient demand on products manufactured by less developed countries (Prebisch, 1962), unequal exchange (Emmanuel, 1972) as well as unpredictable global market (Jaffe, 1985).

In contrast, economic growth has an impact on trade too. This is considered as the link between outward orientation and growth (Edwards, 1993). In empirical studies, however, exports are used as a measurement for the policy of outward orientation. Economic growth may cause an increase in exports due to improvements in domestic labour skills and technologies. For example, Reppas and Christopoulos (2005) examine the exports-growth nexus in some less developed Asian and African countries between 1969 and 1999. The results confirm the fact that economic growth causes exports but not the reverse. Similarly, Love and Chandra (2004), using the Johansen's multivautriate framework, found that both in the long and short-run, income Granger causes exports unidirectionally.

Some researchers find mixed results in the study of the relationship between exports and economic growth. Konya (2006) investigates the causality between exports and national income in 24 developed countries for the period from 1960 to 1997. The results obtained are mixed. In some countries, one-way causality from exports to income is found, while unidirectional causality from income to exports is discovered in others. Moreover, two-way causality between exports and GDP appears in some other countries. However, in the case of six countries, causality does not exist between exports and growth in either direction. Furthermore, by using time series and panel data for the period between 1986 and 2004, Hsiao and Hsiao (2006) discover that the causality is running from exports and GDP and vice versa in eight developing Asian countries.

2.5 The Link between Institutional Quality and Economic Growth

Over the past decades, economists have been studying and attempting to figure out which aspects of a country's economy are the determinants for economic growth as well as to explain the differences in income per capita among nations. Traditionally, the common factors analysed in growth models include labour, human capital, physical capital and technology. However, in recent years, institutional factors such as property rights, legal system and political stability have been incorporated into growth models to complement the more traditional factors. According to Gagliardi (2008), institutions matter because they help to minimise opportunism, to foster cooperative behaviour among agents, and to enable agents internalise externalities. Thus, the improvement of institutional quality can provide a favourable environment that makes cooperative solutions possible. This will in turn help to enhance economic growth.

2.5.1 From Institutional Quality to Growth

Up to date, many researches have been done to study the role of institutions in promoting growth. Most of the studies suggest that institutional factors have a positive and strong impact on a country's economic growth. For example, as proposed by North (1990), property rights play a very important role in explaining growth. According to him, property rights enable resources in the economy to be utilised more efficiently in the sense that it would be channelled towards productive investment instead of unproductive ones.

Apart from that, Clague, Keefer, Knack, and Olson (1995) suggest that institutional quality in an economy is highly influenced by the characteristics and stability of its political system. In addition, Knack and Keefer (1995) employ the International Country Risk Guide (ICRG) rankings to compose an index based on the average of five institutional characteristics such as rules of law, bureaucratic quality and corruption for the period between 1986 and 1995. The results indicate that the ICRG index is strongly correlated with economic growth even after controlling for variables such as education and initial income. Thus, the researchers argue that economic performance of a nation relies very much on its institutional quality.

In the mean time, Mauro (1995) intends to study the link between institutions and economic growth across 70 countries from 1980 to 1983. It appears evident that bureaucratic efficiency leads to increased FDI and in turn higher growth. Moreover, Clague, Keefer, Knack, and Olson (1996) argue that an improved property and contract rights due to democracy helps to stimulate economic growth more than autocracy.

Furthermore, Ulukaev (1997) studies the relationship between democracy and economic development, and concludes that per capita income for a country can be used as an indicator to reflect the type of its socio-political structure accurately. For instance, the author claims that a nation with a per capita GDP higher than $10,000 is always democratic. In contrast, countries with per capita GDP lower than $2,000 do not seem to show any stable democracy. Similarly, Rodrik (2000) emphasises the importance of democracy in stimulating growth. According to the author, democracy can be treated as the meta-institution for creating other good institutions. Evidence from the former socialist countries shows that the most democratic countries have experienced the most successful transitions. It is due to the fact that democracies can help to obtain more predictable long-run growth rates, to enable a greater short-run stability, to better deal with adverse shocks, and to produce better distributional outcomes. Moreover, a very recent research by Knutsen (2012) has concluded that democracy does have a strong effect on economic growth particularly in countries with lower state capacity such as Sub-Saharan Africa, but not in higher state capacity nations. Furthermore, this study suggests that state capacity which is measured by bureaucratic quality index from the ICRG dataset stimulates growth only in dictatorships. However, by using annual institutional data from 1960 to 2004 for 169 countries and at the same employing system-GMM estimator, Aisen and Veiga (2013) find that democracy has a weak negative effect on economic growth.

Lane and Tornell (1996) intend to find out why the growth rates in rich countries are lower if compared to poor countries by taking natural resource abundance and institutions into consideration. Besides, Aron (2000) finds that institutional quality does influence investment as well as growth. The institutional variables considered in this study include respect for contracts and property rights. It is found that the institutional quality affects economic growth indirectly through its impact on the amount of investment (Aron, 2000).

Furthermore, according to Subramanian (2007), public institutions in particular play four important roles in promoting and sustaining long-run development. First, public institutions help to create market by protecting property rights, providing law and order and so forth so that a friendly business environment can be created. Second, institutions can regulate markets by correcting market failures and/or fulfilling some social objectives such as providing education to the needy. Further, institutions like central banks can stabilise markets by ensuring macroeconomic stability in a particular country.

Subramanian (2007) also does a study on several public institutions in India and finds out that there is no improvement in institutional quality despite rapid economic growth for the past 30 years. The researcher concludes that one of the possible reasons that can explain the long run growth is the quality of public institutions that are bequeathed by the country's pre-independence leaders. In addition, this study also points out that economic growth does not automatically lead to improvement in institutional quality in India.

On top of that, Gradstein (2008) argue that a low level of income inequality leads to high institutional quality that can in turn stimulate better economic growth. On the other hand, if income inequality is high, then institutional quality is weakened, and growth would be slow. The author believes that weak institutional quality which is coupled with slow economic growth can persist if nothing is to be done to improve economic condition by reducing income inequality. This can explain why most of the attempts to import some constitutional features such as land reform from the developed to the developing world fail.

Further, Hasan, Wachtel, and Zhou (2009) use a panel of provincial level data from China for the period 1986-2003 to investigate whether the changes in China's legal, economic and political institutions and its financial market can influence the economic performance of the country. It is proven that those regions with better development of financial market, better legal environment, higher awareness of property rights and more open political environment enjoy stronger growth.

Lee and Kim (2009) attempt to identify the determinants for long term economic growth in different countries in relation to income levels. By using system-GMM estimations, the researchers point out that institutional quality is one of the main factors affecting long term growth by holding the initial income levels, population and geography constant. Other significant variables include technology and tertiary education. Apart from that, they also found that different countries possess different determinants for growth depending on their stage of development. The results show that institutions and secondary education matter the most for lower- income nations. However, for the higher-income nations, technology and higher education are more important factors stimulating growth.

Some researchers who study the impact of institutional quality on growth believe that different institutional variables may not have equal importance in a growth model. They argue that the significance of an institutional factor relies on the income level of a country. For example, by adopting six different institutional indicators representing different institutional dimensions such as rule of law and control of corruption, Aixala and Fabro (2008) attempt to identify the most important institutional variables to be included into a growth model for both rich and poor countries. Firstly, they confirm that institutional quality is a vital determinant for economic growth of countries. Further, the results indicate that among the six variables examined, 'control for corruption' is the most significant variable for poor countries while the most important factor for rich countries is 'rule of law'. These findings are consistent with the results of some previous studies. For instance, Butkiewicz and Yanikkaya (2006) obtain the same result by concluding that the significance of 'rule of law' can only found in developed countries. The importance of corruption for poor countries is also highlighted in the study by Tanzi and Davoodi (2002). The result of their study shows that corruption can dampen the growth of poor countries as well as transitional economies by hindering the development of small and medium businesses.

This is due to the fact that corruption diverts resources into unproductive activities such as rent seeking.

An interesting contribution on issue of the importance of institutions has been done by Keefer and Shirley (2000). They discover that countries with superb security of contracts and property rights are able to achieve much better economic performance as compared to countries without good institutions. A further analysis carried out by the authors using a group of 84 countries for the period between 1982 and 1994 suggests that good macroeconomic policies may not be efficient if their implementation is not complemented by favourable institutional quality.

By using a panel data of 25 years, the study by Addison and Baliamoune-Lutz (2006) for the case of three Maghreb's nations (Algeria, Morocco and Tunisia) suggests that an inverted-U relationship is confirmed between institutions and economic growth. The result indicates that as countries shift from the worst institutional quality to partial freedom, the per capita income tends to increase initially. However, within the second half of the partially free range, income tends to decline because institutional quality does not show much improvement. This implies that a 'partial improvement' may be more inferior than a weak institutional quality in terms of economic performance. According to the researchers, there are two main reasons for the inverted-U relationship. First, productivity suffers as people may be unhappy with government policies since they perceive these policies benefit only the minority who are in power as corruption and human rights abuse still exist.

Second, the rich and wealthy may feel threatened with improved institutional quality. Hence, they are encouraged to contribute less to the development of the country and even shift their productive resources abroad.

By focusing on Mexico, Angelopoulos, Economides and Vassilatos (2010) examine the role of institutions particularly property rights in explaining economic fluctuations in the emerging economies. The result of the study shows that changes in Mexico's productivity are related to shocks in institutional quality. As a conclusion, weak property rights are unfavourable for the performance of an economy. This conclusion obtained is consistent with the earlier research done by Bergoeing, Kehoe, Kehoe, and Soto (2002) who proposed that improvements in institutional quality such as privatisation and regulation of banking system lead to total factor productivity movements, which in turn help to explain economic volatility in Chile and Mexico. Besides, Acemoglu, Johnson, Robinson, and Thaicharoen (2003) hold the same view by suggesting that less established institutions can help to explain economic fluctuations in a cross section of countries. In short, they conclude that the overall performance of an economy depends very much on its institutional characteristics. Other empirical studies on the role of property right include researches by Claessens and Laeven (2003) and Johnson, McMillan, and Woodruff (2002). For example, Johnson et al. (2002) discover that property rights can be an extremely important variable in determining growth in a country. Further, Claessens and Laeven (2003) suggest that better property rights can bring about higher growth through operational improvement in the financial sector by studying data from both developed and developing countries.

Recently, Siddiqui and Ahmed (2013) investigate the extent to which institutions affect growth by using 31 institutional indicators covering 84 countries for 5-year period from 2002-2006. Various categories of institutional factors namely, political rents, institutional and policy rents, and risk-reducing technologies have been extracted from the indicators based on principal component analysis. The results obtained by applying the methodologies of panel OLS and GMM have supported the fact that good institutions lead to better economic growth. In particular, institutional and policy rents are more important factors contributing to growth than the other two factors in developing countries.

2.5.2 From Growth to Institutional Quality

Some other researchers believe that as nations experience better growth, institutional quality will tend to improve because when people become more well off, they will demand more from their institutions. For instance, Barro (1996) claims that a higher income will lead to a greater political freedom in a particular country. In other words, as nations experience better growth, they will become more democratic in the sense that more political freedom will be given to the citizens. Acemoglu, Johnson, and Robinson (2001) also agree to the point of view that as income rises, institutions improve while studying the role of institutions in explaining long-run growth. Furthermore, Rigobon and Rodrik (2004) conduct a study on Korea and found that as income grows higher in the country, the costs of doing business drop. Hence, it can be concluded that as income increases, the quality of institutions improves. In addition, by analysing the data from South and North Korea, Glaeser, Porta, Lopez-de-Silanes, and Shleifer (2004) suggest that economic growth leads to better institutions such as democracy. On the other hand, improvement in institutional quality does not help to explain economic growth. Instead, human capital plays a more important role in stimulating growth.

As a conclusion, there is no clear consensus on whether better institutional quality leads to higher growth or economic growth causes improved institutional quality. However, from the above discussion, most of existing literature agree with the idea that institutional quality plays a vital role in contributing to better economic performance.

2.6 The Impact of Inflation on Economic Growth

In the recent decades, an abundant of researches has been done attempting to figure out the relationship between inflation and economic growth. However, mixed results have been obtained by these studies and the issue on how does inflation affect economic growth remains controversial.

The existing literature on the inflation-growth nexus has basically shown four possible outcomes (Vinayagathasan, 2013). First, inflation is found to have no influence on economic growth (e.g., Bruno & Easterly, 1998; Cameron, Hum, & Simpson, 1996).

Second, inflation affects economic growth positively. Researchers who find a favourable impact of inflation on economic growth include Mallik and Chowdhury (2007) and Shi (1999).

Third, there is a negative link between inflation and economic performance. Many studies have revealed such a relationship (e.g., Barro, 1991; De Gregorio, 1992; Fischer, 1993; Saeed, 2007). A more recent research by Bittencourt (2012) also discovers that inflation has an unfavourable impact on economic growth in Latin American countries. The results are obtained using panel time-series data and analysis over the period 1970-2007.

The last possibility suggests that the two variables—inflation and economic growth are in fact nonlinearly correlated. In other words, the relationship between inflation and economic growth remains nonexistent or positive before a threshold of inflation is reached. However, beyond a certain critical level, inflation leads to lower economic growth. Numerous studies such as Eggoh and Khan (2014), Gillman and Kejak (2005), Khan and Senhadji (2001), Lopez-Villavicencio (2011) and Sarel (1996) have confirmed the existence of such a non-linear relationship between inflation and economic growth. For instance, two major findings are shown in the most recent study by Eggoh and Khan (2014) considering 102 developed and developing countries for the period between 1960 and 2009. Most importantly, the results indicate that the nonlinear link between inflation and economic growth depends very much on country-specific characteristics such as trade openness and capital accumulation. Furthermore, it is also shown that due to differences in country specific characteristics, the nonlinear relationship varies among countries.

2.7 CO2 Emissions, Foreign Direct Investment and Economic Growth

There are two different and contradicting views on how foreign direct investment affects CO_2 emission. First, foreign direct investment may lead to an increase in national output, and in turn causes an increase in CO_2 emissions. Second, more efficient production technology may be used as a result of foreign direct investment, and thus causes a reduction in per capita CO_2 emission (Stretesky & Lynch, 2008).

According to Jensen (1996), even though FDI can contribute to better economic performance, it may lead to deterioration in environmental quality. Furthermore, in order to reduce cost on environmental controls, polluting industries and businesses will tend to be shifted to less developed countries with low environmental standards, and then turn these countries into pollution slums. This view is supported by both Xing and Kolstad (2002) and Zhang (2011) who report that a direct relationship exists between FDI and pollution.

Moreover, Acharyya (2009) studies the impact of foreign direct investment (FDI) on both GDP growth and environmental degradation in India. The researcher finds a positive though marginal, long run impact of FDI on economic growth in India from 1980 to 2003. On the other hand, the results also show that there is a strong FDI-led growth impact on the CO_2 emission in the long-run. However, by examining the composition of FDI inflow and the share of dirty industries in total FDI inflow, the researcher points out that the pollution heaven hypothesis is not valid in the case of India, at least since mid-1990s. In fact, there has been a relative decline in FDI inflow into the so called dirty industries since 1998. There are two possible explanations for this phenomenon. First, goods produced by dirty industries have a low income elasticity which means less demand in developed countries. Second, environmental regulation has probably caused some of the pollution-intensive industries to move from India to other countries.

Furthermore, Kim, and Baek (2011) study the impact of income on environment for developed and developing countries for the period 1971 to 2005. For the purpose of this study, ARDL approach to cointegration has been used with the incorporation of FDI as a control variable. The study concludes that FDI does not cause an essential impact on environmental quality in most of the developed and developing countries studied in both the short- and long-run. Similarly, a recent study by Lee (2013) using panel data from 19 G20 countries covering 1971 to 2009 have also shown evidence that FDI does not lead to a direct positive effect on CO_2 emission even though FDI does contribute to better economic growth. The author argues that the use of new technologies due to FDI may have led to more efficient use of energy resources and subsequently a reduction in CO_2 emission.

2.8 CO_2 Emissions, Exports and Economic Growth

So far, several researches have been carried out looking at international trade in the context of the EKC hypothesis. In fact, the impact of trade on pollution has been studied from different perspectives. First of all, according to Antweiler, Copeland, and Taylor (2001), trade openness may lead to a reduction in pollution emissions as enhanced competitive pressure may encourage countries to utilise their resources more efficiently. This view is supported by Shahbaz, Lean, and Shabbir (2012) who find that trade openness contributes positively to environmental quality in Pakistan with the use of cleaner production technologies. Similar results are obtained by Shahbaz, Hye, Tiwari, and Leitao (2013) for the case of Indonesia while investigating the linkages between economic growth, trade openness, CO_2 emission, energy consumption and financial development over the period of 1975 to 2011 employing ARDL bounds testing approach to cointegration.

However, a recent study by Atici (2012) suggests that exports as a percentage of the gross domestic product do contribute to an increase in CO_2 emissions in ASEAN countries. Interestingly, the study also discovers the fact that exports of ASEAN countries to Japan do not lead to pollution while exports of ASEAN countries to China has contributed to higher CO_2 emissions.

Apart from this, some other researchers have come out with a more systematic analysis between trade and pollution. Copeland and Taylor (2004) and Grossman and Krueger (1991) suggest that the impact of trade liberalisation on environmental quality can be divided into three independent effects. First, the scale effect occurs when higher scale of economic activity due to increased market access leads to a rise in pollution. Second, the technique effect refers to the adoption of environmentally beneficial techniques of production which follows trade liberalisation. The modern and cleaner technologies are transferred from developed to less developed countries. Third, the composition effect reflects change in structure of the economic activity followed by liberalised trade as nations begin to increasingly specialise in sectors with comparative advantage.

If a comparative advantage is generated for differences in environmental regulations, then there will be a tendency for carbon-intensive industries to move from nations with stricter environmental laws to those nations with lower environmental standards. This effect is coined Pollution Haven Hypothesis (PHH). Assuming that environmental laws become more stringent with income, the hypothesis suggests that developing countries will gain comparative advantage and specialise in "dirty" products while developed nations will import these products from the developing world. According to Cole (2004), the cost of meeting environmental standard in the developed world is increasing over time. For example, USA alone bears $184 billion of such costs in 2000. However, such costs are far lower in most of the developing countries. Thus, these developing countries may have the comparative advantage in pollution-intensive production.

In fact, the PHH is merely part of a wider concept called "carbon leakage" (Webers & Peters, 2009). A positive carbon leakage means a net increase in global CO_2 emissions.

Over the past 30 years, there has been a shift of world production from wealthy developed countries such as U.S. to poor undeveloped nations with relatively lower production costs and/or looser environmental regulation. This also indicates that there is a redistribution of global CO_2 production. For example, the shift of U.S. industries to developing countries that have become the main producers for world manufactured goods has caused CO_2 levels to accelerate in these nations (Stretesky & Lynch, 2008).

If the pollution haven hypothesis is valid, then the downward sloping portion of EKC may not mean a net reduction in pollution emissions, but merely a transfer of pollution from the developed to the developing world with lower environmental standards. In other words, the PHH reminds us to be more sceptical about the simple and predictable relationship between economic growth and environmental degradation which is depicted by the inverted U-shaped EKC. At the same time, Cole (2004) claims that if PHH does contribute to the EKC inverted U relationship, then the EKC does not indicate that a rise in income will grant an automatic solution to the environmental problem. Instead, it simply indicates that as income grows, the developed nations export their pollution-intensive industries to less developed nations. Unfortunately, this may also mean that today's less developed nations will have no place where their "dirty" industries can be shifted to. Therefore, it is predicted that the current developing countries are not likely to pursue the same income-pollution path as today's developed countries.

However, mixed results have been obtained for PHH so far. Antweiler (1996) finds that developed countries export more "dirty" products than they import. This implies that the PHH cannot be supported. Likewise, Janicke, Binder, and Monch (1997) suggest that the stringency of a nation's environmental rules has nothing to do with the trade in pollution-intensive products. In addition, Kearley and Riddel (2009) test the influence of international trade on the shape of EKC in developed countries. The result shows that the PHH does not play a vital role in influencing the EKC. In contrast, Birdsall and Wheeler (1993) discover that as environmental regulations in OECD countries were tightened, the growth in pollution intensity in developing countries increased. By using a combined time-series and cross-section model, Chapman and Suri (1998) claim that trade is responsible for both the upward and downward portions of the EKC. On top of that, by utilising data for 18 developed nations, Muridian, O'Connor, and Martinez-Alier (2002) study embodied pollution in imports and exports of these countries with developing countries between the period 1976 to 1994 and find some evidence for the impact of trade. Furthermore, Cole (2004) examines the impact of trade on pollution emissions with the data of ten air and water pollutants. The researcher finds evidence for the existence of PHH, but the effects are seemed to be small.

There are several reasons that can explain the inconclusive evidence about the existence of PHH. One explanation is that environmental regulations are considered as an endogenous variable and treated as a secondary trade barrier to protect local industry in certain countries such as U.S. (Ederington & Minier, 2003). In such a case, environmental regulations will tend to have a great impact on trade. Another reason for the non-existence of PHH is that as costs of environmental compliance constitutes a small portion, that is, usually less than 2% of total production cost, therefore, they are do not have much influence on international competitiveness (Jaffe, Portney, Peterson, & Stavins, 1995). Finally, developing countries may have some unfavourable characteristics such as corruption and lack of infrastructure that hinder investors from developed countries to invest in these countries (Cole, 2004).

Shui and Harriss (2006) found that U.S.-China trade led to an increase in global CO2 emission by about 720 million metric ton from year 1997 to 2003. According to them, this phenomenon is due to the substitution of less polluted manufacturing techniques in the U.S. industries with the dirtier Chinese ways of production that rely heavily on coal for energy production.

Further, in examining the relationship between CO_2 emissions and exports to the U.S. for 169 countries between 1989 and 2003, Stretesky and Lynch (2008) confirm a positive relationship between the two variables.

However, according to this research, not all exports to the United States cause such a relationship. The analysis shows that CO_2 emissions in the exporting counties are specifically more influenced by U.S. imports in products such as oil and gas, petroleum and coal. These results imply that consumption pattern in the U.S. has significant impact on the global level of CO_2 emission. The authors also suggest that those developing countries who are the main exporters can help to influence U.S. CO_2 emission by reducing exports to the U.S.

2.9 CO_2 Emissions, Institutional Quality and Economic Growth

Based on the research done by Panayotou (1997), the quality of both policies and institutions plays an important role whereby it helps to reduce environmental degradation in a country even if it is a poor country. This means that countries can expect to enjoy improvements to the environment with higher future income levels. The policies mentioned include more secure property rights. These policies may lead to the flattening of EKC and improve the environmental quality at higher economic growth.

Similarly, Torras and Boyce (1998) suggest that institutional factors such as a fairer distribution of income contributes positively to the EKC relations as they analyse seven air and water pollutants by making a comparison between high-income and low-income countries. Their study also shows that factors like literacy and political rights lead to a significant effect on the quality of environment in low income countries.

Furthermore, Tamazian and Rao (2009) study the relationship between pollution and economic growth by considering additional variables namely, financial developments and institutional quality using GMM. The relationship between GDP and pollution is examined by using 24 transition countries covering 1993 to 2004. The results confirm the validity of EKC hypothesis.

Most recently, a study is done by Leitao (2010) to examine the effect of corruption on economic growth using sulphur emissions as the pollutant. A total of 94 countries with different stages of development that coupled with varying degrees of corruption are chosen for this study. The results indicate that EKC hypothesis does exist for sulphur. The results obtained above are consistent with the findings of Lopez and Mitra (2000) who discover that an inverted U-shaped EKC does exist between pollution and economic growth despite corruption. However, it requires a higher income level and a higher degree of pollution to achieve the turning point of EKC.

Besides, Deacon (1999) finds that in countries with less democratic rights, environmental quality will tend to be lower. In a similar vein, Eriksson and Persson (2003) mentioned that a more equitable income distribution can lead to a lower level of pollution in countries with "complete" democracy. However, in countries with "incomplete" democracy, the result is reversed.

Carlsson and Lundstrom (2003) propose the Political Freedom Index and explain that countries with a higher level of political freedom will tend to have better environmental quality because people are allowed to speak their mind on environmental issue. Furthermore, Neumayer (2003) and Neumayer (2004) propose that it is more possible for left wing governments who are generally driven by the poor and working class's interests to protect the environment so that these blue collar workers would not suffer from environmental degradation. In addition, Klick (2002) also claims that a dictator is highly motivated to protect the environment in order to stay in power because the dictator has limited amount of tools in hand for him to do so. For instance, the dictator would prefer to spend more on environmental protection instead of other types of public amenities such as schooling. However, Congleton (1992) has a different view on this and points out that autocratic rulers lead to lower environmental quality as the researcher believes that these dictators would have a shorter time horizon.

A recent study by He and Wang (2012) utilising data of 74 cities in China for the period 1991 to 2001 indicates that development policies such as environmental enforcement capacity can influence the pollution-income relationship. The results show that reinforcing environmental regulation tends to improve environmental quality only after certain levels of income have been achieved.

From the above discussion, it can be noticed that some common but yet important institutional variables such as law and order, corruption level, level of democracy, and property right have been utilised extensively in the past studies. Most of the researches suggest that proper institutional quality may lead to a favourable relationship between CO_2 emissions and economic growth. In other words, it is possible for the combination of low pollution and high growth to be achieved with the presence of good institutional quality.

2.10 Conclusion

The above review of literature proves the fact that the results are found to be inconclusive not only for the case of Environmental Kuznets Curve. In regards to the EKC, there are four common patterns discovered, namely inverted U-shaped, monotonically increasing, monotonically decreasing and N-shaped. The shape varies depending on factors such as choice of pollutant, countries selected and the quality of institutions. It is also mentioned in the literature that the studies of EKC hypothesis has received some criticisms based on theoretical and methodological grounds. In addition, when it comes to the relationship between FDI and economic growth as well as exports and economic growth, it is also discovered that the results obtained are mixed. On the other hand, most of the past researches agree to the point that institutional quality is a vital element contributing to growth. Most importantly, it has been suggested by the existing literature that proper institutional quality in a country may lead to a favourable relationship between CO_2 emissions and economic growth. The summary of the past studies is presented in Table 2.1 to Table 2.3.

This study intends to fill some of the gaps of the past researches. First, the study considers three additional variables that is, institutional quality, FDI and trade openness as control variables in the EKC analysis. Besides, instead of examining merely the impact of income on CO_2 emission using EKC analysis, effort is extended to investigating the feedback effect of CO_2 emissions on economic growth. Next, in view of the importance of institutional quality in stimulating growth and at the same time helping in maintaining good environmental quality, it has been included in the growth model of the study.

In short, the study attempts to examine the shapes of EKC in different countries and to investigate the role of institutional quality in influencing the impact of CO_2 emission on economic growth using panel data analysis. The details of the models constructed and methodology employed are presented in Chapter3.

Table 2.1: Summary of Studies on the Income-Pollution Nexus

Authors	Variables	Period	Countries	Methodology	Results
Grossman and Krueger (1993)	GDP and SO_2 dioxide emissions	1977	42 cities in developed and developing countries	Random effects models	Inverted U-shaped
Moomaw and Unruh (1997)	GDP and CO_2 emissions	1950-1992	16 OECD countries	-Non-linear Dynamical Systems Approach -Econometric Modeling Approach	-Inverted-U shaped pattern in majority of the countries (for the period from 1974 to 1975 due to the impact of oil crisis) -N-shaped relationship (when cubic EKC model is applied to all countries)
Roberts and Grimes (1997)	CO_2 emissions intensity and GDP	1962-1991	147 developed and developing countries	Ordinary Least Squares (OLS) estimator	- Inverted-U shaped (high income countries) -Positive linear relationship (middle and low income countries)
Dijkgraaf and Vollebergh (1998)	GDP and CO_2 emissions	1960-1990	OECD countries	Pooling techniques	Inverted U-shaped

Schmalensee, Stoker, and Judson (1998)	GDP and CO_2 emissions	1950-1990	47 developed and developing countries	Reduced-form models	Inverted U-shaped
Bengochea-Morancho, Higon-Tamarit and Martinez-Zarzoso (2001)	GDP and CO_2 emissions	1981-1995	10 European Union (EU) nations	Ordinary Least Squares (OLS) estimator, Fixed Effects method (FE), Random Effects method (RE), and Two Stages Least Squares (TSLS)	Richer countries are more polluted than poorer countries
Dijkgraaf and Vollebergh (2001)	GDP and CO_2 emissions	1960-1997	24 OECD countries	Spline function approach	Inverted U-shaped does not exist
Gangadharan and Valenzuela (2001)	GDP, CO_2 emissions and health indicators	1980-1995	51 OECD and non-OECD countries	Two-Stage Least Squares Model	Positive linear relationship between GDP and CO_2 emissions
Lindmark (2002)	GDP and CO_2 emissions	1870-1997	Sweden	Dynamic Structural Model	Inverted-U shaped relationship does not exist (no turning point found)
Friedl and Getzner (2003)	GDP, CO_2 emissions, Trade and Structural Change	1960-1999	Austria	Stationarity and Cointegration Analysis	N-shaped relationship

Kristrom and Lungren (2003)	GDP and CO_2 emissions	1900-1999	Sweden	Growth-theoretic model	Inverted U-shaped
Martinez-Zarzoso and Bengochea-Morancho (2004)	GDP and CO_2 emissions	1975-1998	22 OECD countries	Pooled Mean Group Estimator	N-shaped relationship
Aslanidis and Xepapadeas (2005)	SO_2 emissions,NO_2 emissions and GDP	1929-1994	48 states in U.S.	Regime Switching Approach	-Inverted V-shaped (SO_2 emissions) - Positive link between NO_2 emissions and GDP
Galeotti, Lanza, and Pauli (2005)	GDP and CO_2 emissions	1960-1998 (OECD) 1971-1998(Non-OECD)	OECD and Non-OECD countries	Three-parameter Weibull function	-Inverted U-shaped (OECD countries) - Positive relationship (Non-OECD countries)
Lantz and Feng (2005)	GDP, CO_2 emissions, Population density and Technology	1970-2000	Canada	Examines a more flexible model applying a five-region panel data set	Income is unrelated to CO_2 emissions
Soytas, Sari, and Ewing (2006)	GDP, CO_2 emissions and energy consumption	1960-2004	United States	Granger causality test	Income does not Granger cause CO_2 emissions

Cialani (2007)	GDP and CO_2 emissions	1861- 2002	Italy	Index Decomposition Analysis (IDA)	Positive linear relationship
Huang , Lee, and Wu (2007)	GHG emissions and GDP	1993-2003	Economies in Transition (EITs) and Annex II countries	-Plotted GDP as x-axis and GHG emissions as y-axis to show trends -Curve fitting	-Quasi-L-shape curve (EITs) -Mixed results (Annex II countries)
Akbostanci , Turut-Asik, and Tunc (2008)	GDP and CO_2 emissions	1968-2003	Turkey	Cointegration analysis	Positive linear relationship
Hu and Huang (2008)	GDP and CO_2 emissions	1980-2005	31 provinces in China	-Simple Regression - Decomposition Analysis of CO_2 emissions	N-shaped relationship
Rezek and Rogers (2008)	GDP and CO_2 emissions	1971-2000	A panel of industrialized countries	Structural Production Model	Positive linear relationship (In most countries)
He and Richard (2009)	GDP and CO_2 emissions	1948- 2004	Canada	Semi Parametric and Flexible Nonlinear Modelling Methods	Positive linear relationship
Jalil and Mahmud (2009)	GDP and CO_2 emissions	1971-2005	China	Granger causality test	GDP→ CO_2 emissions

Lamla (2009)	GDP and CO_2 emissions	1980-2000	47 countries	Bayesian Averaging of Classical Estimates (BACE)	Inverted U-shaped
Narayan and Narayan (2010)	GDP and CO_2 emissions	1980-2004	43 developing countries	Panel cointegration and the panel long run estimation techniques	15 out of 43 countries have experienced a decline in CO_2 emission over time with a rise in income
Jaunky (2011)	GDP and CO_2 emissions	1980-2005	36 developed countries	VECM causality test	GDP$\rightarrow$ CO_2 emissions
Niu, Ding, Niu, Li, and Luo (2011)	GDP and CO_2 emissions	1971- 2005	8 Asia-Pacific countries	Granger causality test	GDP$\rightarrow$ CO_2 emissions
Ahmed and Long (2012)	CO_2 emissions, economic growth, energy consumption, trade liberalization and population density	1971-2008	Pakistan	Auto Regressive Distributed Lag (ARDL) methodology	Inverted U-shaped
Saboori, Sulaiman, and Mohd (2012)	GDP and CO_2 emissions	1980-2009	Malaysia	Auto Regressive Distributed Lag (ARDL) methodology	Inverted U-shaped

Zanin and Marra (2012)	GDP and CO_2 emissions	1960-2008	9 developed countries	Flexible additive mix models	-Inverted U-shaped (France & Switzerland) - Increasing relationship (Australia, Italy & Spain) - N-shaped (Austria)
Shahbaz, Mutascu, and Azim (2013)	Economic growth, energy consumption and CO_2 emissions	1980 -2010	Romania	Auto Regressive Distributed Lag (ARDL) methodology	Inverted U-shaped

Table 2.2: Summary of Studies on the Institution-Growth Nexus

Authors	Variables	Period	Countries	Methodology	Results
Knack and Keefer (1995)	An institutional index based on the average of five institutional characteristics (such as rules of law, bureaucratic quality and corruption) and economic growth	1986-1995	United States	OLS estimator	Institutional quality is highly correlated with economic growth
Keefer and Shirley (2000)	Security of contracts, property rights and economic performance	1982-1994	84 countries	OLS estimator	Better institutional quality→ economic growth
Bergoeing, Kehoe, Kehoe, and Soto (2002)	Institutional quality, total factor productivity and economic volatility	1980-2000	Chile and Mexico	Growth accounting and a calibrated dynamic general equilibrium model	Institutional quality→ economic volatility
Tanzi and Davoodi (2002)	Corruption, economic growth and public finances	1980-1997	97 countries	Correlation Analysis	Corruption→ slower growth in poor countries
Glaeser, Porta, Lopez-de-Silanes,	Institutions and economic growth	1960-2000	South and North Korea	OLS estimator	- Economic growth leads to better institutions such as

and Shleifer (2004)					democracy - Institutional quality does not help to explain economic growth
Rigobon and Rodrik (2004)	Economic institutions, political institutions, openness and economic growth	1980-1999	70 colonised and 168 non-colonised countries by European powers	- OLS estimator - Identification through heteroskedasticity (IH) estimation	- Democracy and rule of law→ economic growth - Institutions have even strong impact on economic growth
Butkiewicz and Yanikkaya (2006)	Rule of law, democratic institutions and economic growth	1970-1999	100 countries	SUR Technique	-Rule of law→ economic growth -democratic institutions do not lead to economic growth
Subramanian (2007)	Institutions and economic growth	1970-2005	India	OLS estimator	Better quality of public institutions→ long run growth
Aixala and Fabro (2008)	Institutional variables and economic growth	1975-2000	Rich and poor countries	OLS estimator, 2SLS estimator and GMM estimator.	-Better institutional quality→ economic growth -'control for corruption' is the most significant variable for poor countries - the most important factor for rich countries is 'rule of law'

Hasan, Wachtel, and Zhou (2009)	Legal institutions, financial deepening, political pluralism and economic growth	1986-2003	Provinces in China	-OLS estimator -System-GMM estimator	Better legal environment and better property rights→economic growth
Lee and Kim (2009)	Institutional quality, economic growth, technology and tertiary education	1965-2002	Four different income groups based on World Bank's Income Group Classification	-OLS estimator -System-GMM estimator	-Better quality of institutions→ long run growth - Institutions are important for growth in low income countries
Angelopoulos, Economides and Vassilatos (2010)	Economic fluctuations and property rights	1980-2005	Mexico	Calibration	Property rights→ economic fluctuations
Knutsen (2012)	Democracy, state capacity and economic growth	1972-2005	Sub-Saharan countries	-OLS estimator -Fixed Effects (FE) estimator	Democracy→ economic growth in countries with low state capacity
Aisen and Veiga (2013)	Democracy and economic growth	1960 -2004	169 countries	System-GMM estimator	Democracy has a weak negative effect on economic growth
Siddiqui and Ahmed (2013)	31 institutional indicators and economic growth	2002-2006	84 countries	-OLS estimator -System-GMM estimator	Better institutional quality→ economic growth

Table 2.3: Summary of Studies on Pollution, Institutional Quality and Economic Growth

Authors	Variables	Period	Countries	Methodology	Results
Torras and Boyce (1998)	Pollution, income, income inequality, literacy, political rights & civil liberties and urbanisation	1977-1991	58 countries	Ordinary Least Square (OLS) estimation and Generalised Least Square (GLS) estimation	-A fairer distribution of income contribute positively to the EKC relations - Literacy and political rights lead to a significant effect on the quality of environment in low income countries
Deacon (1999)	Democracy, economic growth and pollution	1972-1992	48 countries	Fixed effects estimation	Countries with less democratic rights, environmental quality will tend to be lower
Carlsson and Lundstrom (2003)	CO_2 emissions, economic freedom, institutions and political freedom	75 countries	1975-1995	Box-Cox estimations	Countries with a higher level of political freedom will tend to have better environmental quality
Neumayer (2004)	Environment and Left wing	62 countries	1981–1984, 1990–1993 and 1995–1997	Survey data analysis from the World and European Values Surveys	Left- wing governments who are generally driven by the poor and working class's interests to protect the environment

Tamazian and Rao (2009)	Pollution, economic growth, financial developments and institutional quality	1993 -2004	24 transition countries	System-GMM estimator	Confirms the importance of institutional quality in reducing CO_2 emissions
Leitao (2010)	Corruption, economic growth and sulphur emissions	1981-2000	94 developed and developing countries	Random effects estimation	An inverted U-shaped EKC does exist between pollution and economic growth despite corruption
He and Wang (2012)	Development policy, economic structure, pollution and economic growth	74 cities in China	1991- 2001	Fixed and random effects estimation	Reinforcing environmental regulation tends to improve environmental quality only after certain levels of income have been achieved.

CHAPTER 3

THEORETICAL FRAMEWORK AND METHODOLOGY

3.1 Environmental Kuznets Curve (EKC) Hypothesis

A vast amount of researches[14] have been done on the income-pollution nexus ever since the pioneering research by Grossman and Krueger (1991). Majority of the studies concentrate on examining the existence of an inverted U-shaped link between GDP and pollution. However, the results obtained from these studies have been mixed so far. Some studies show support for the existence of EKC[15] while others found monotonic, negative or even N-shaped relationship between income and CO_2 emission.[16]

In the case of EKC, it is suggested that at the early stage of economic growth, pollution tends to worsen as income increases. However, as income increases further, there will be tendency for environmental quality to improve. There are several main reasons that have been advanced by researchers to explain the EKC relationship.

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[14] Refer to Chapter 2 (2.2) for examples.
[15] See e.g. Dinda and Coondoo (2006), Managi and Jena (2008), Panayotou (1997), and Shafik and Bandyopadhyay (1992).
[16] Refer to Chapter 2 (2.2.3, 2.2.4 and 2.2.5) for examples.

At the early stage of economic development without structural and technological changes, as the scale of the economy increases, environmental quality declines. This is called the scale effect. Later, as economy grows to a certain level, both structural and technological changes that occur in the economy lead to a decrease in environmental degradation eventually (Panayotou, 1993).

De Bruyn (1997) and Grossman (1995) develop structural models that suggest for three main linkages between income and pollution. These three linkages include scale effect, composition effect and technology or productivity effect. Based on the scale effect, it is believed that as the amount of outputs and inputs rise in the economy, environmental quality will tend to decline. The composition effect implies structural change that happens in the economy. Pollution declines as the structure of the economy evolves from industrialisation to services and knowledge technology-intensive industry (Rezek & Rogers, 2008). The technology or productivity effect implies that as rich countries are able to invest more on research and development (Komen, Gerking, & Folmer, 1997), economic growth leads to technological progress that replaces obsolete and dirty technologies with new and cleaner technologies, which improves environmental quality (Dinda, 2004). In addition, Stern (2004) introduces input mix effect, explaining how environmentally harmful inputs are substituted with environmentally less harmful inputs. The Environmental Kuznets Curve suggests that in initial stage of growth, the scale effect tends to prevail, but both the composition and technology effects will eventually outweigh it that lower the pollution level

(Vukina, Beghin, & Solakoglu, 1999). Further, Stern (2004) states that scale effect will tend to outweigh the composition and technological effects in those fast growing middle income nations. However, in high-income countries with low economic growth rates, the technological change may be greater than the scale effect.

On the other hand, World Bank (1992) proposed that the existence of EKC hypothesis is due to a positive income elasticity for environmental quality. This implies that as income grows, people would prefer to have better environmental quality. In such a case, the environment can be considered as a luxury product. At the early stage of economic development, people are not willing to forgo consumption in order to invest in environmental protection. This results in a rise in pollution. However, as people reach a certain income level, demand for better environmental quality increases. This helps to reduce environmental degradation.

Apart from that, according to Focacci (2003), the subsequent improvements in the environmental situation with rising levels in per capita income in the Environmental Kuznets analysis are due to several structural joint causes that include positive value of income elasticity towards environmental quality.

In addition, Dinda (2004) intends to explain the inverted U-shape relationship between economic growth and pollution with an endogenous growth model. Instead of concentrating on the amenity value of environment, the author sees the environment as a productive asset. To achieve long term growth, it is vital to have sustainability in both man-made capital (physical and human capital) and natural capital (environmental assets). Less developed countries tend to use all of their capital for the purpose of commodity production that enhances pollution and in turn destroys their existing environmental stock. This study points out that it is important to allocate part of the capital for abatement activities. According to the researcher, pollution level increases at the early stage of economic development because investment in abatement activities is still lacking. However, the environmental quality improves at the later stage of development because of sufficient investment in abatement activity. It is concluded that the conversion from insufficient to sufficient use of capital to upgrade the environmental quality can explain the inverted U-shape link between income level and environmental degradation.

Furthermore, Cialani (2007) points out that there are two explanations for the shape of EKC. The first one reflects the development paths taken by developed countries as they transformed from agriculture-based economies into industrialisation. The second explanation refers to people's preference over environmental quality when income rises.

In an earlier study, however, Baldwin (1995) explains that the EKC is in fact another expression of "stages of economic development" in an economy. As the economy is transformed from agriculture-oriented to industries and then services, an inverted-U EKC can be observed. The shift from agriculture to industries enhances pollution. However, the movement from industrries to services tends to improve environmental quality. Similarly, according to Focacci (2003), the model of Environmental Kuznets Curve shows an inverted U-shaped pattern due to transition from less developed economic systems towards the current more developed economic systems (Focacci, 2003).

In a nutshell, there are four main reasons that can explain the inverted EKC. First, when nations reach a sufficiently high level of income, people will tend to have an increasing appreciation on the environmental quality. Therefore, as an income threshold is reached, there would be an elastic demand for good environmental quality (Roca, 2003). Second, pollution tends to rise as a country moves from agricultural to energy intensive industrial-based kind of economy. However, when the structure of the economy changes further, that is from industry to services, environmental degradation begins to fall. Third, as income reaches a high level, nations will start to adopt political systems and cultural values that can help in the introduction of environmental-friendly policies in the economy. Fourth, as income grows, nations will have the ability to replace obsolete and dirty technologies with the latest and much cleaner technologies that can improve environmental quality eventually.

In addition, the important implication of EKC in policy forming has motivated researchers and policy makers to investigate the relationship between economic development and CO_2 emission. For instance, by using EKC hypothesis, the prediction on the relative level of environmental damage can be done by looking at GDP per capita (Cialani, 2007).

According to Galeotti et al. (2005), the inverted U-shaped EKC implies that GDP can be both the cause and the cure of pollution problem. This argument would discourage developing countries from complying to emission reduction targets set under the Kyoto Protocol. Moreover, the inverted U-shaped may also show that emissions would automatically decline as GDP increases. In other words, if this hypothesis is assumed to be true, then countries may be able to enjoy higher income and better environment simultaneously over the long run. Most importantly, it is not necessary for countries particularly developing nations to come out with comprehensive environmental policies to combat pollution. Environmental problems can be solved automatically as income rises over time. Further, the identification of the "turning point" would allow someone to precisely know the location of a nation along the curve.

According to Munasinghe (1995), if inverted U-shaped EKC does exist, then developing countries may learn past lessons of developed nations by getting rid of environmentally harmful subsidies. By doing so, the level of emission in developing countries may not go beyond the ecological threshold and thus the deterioration of environmental quality can be prevented.

In view of the importance of EKC, therefore, it is crucial to re-examine the relationship between income and CO_2 emission so that more conclusive results can be obtained. Furthermore, since the previous studies that are based on different time periods, countries, types of pollutants and econometric techniques on the subject have shown mixed results, a re-examination of the nexus is required to deliver results that can produce policy recommendation to be applied across countries. Thus, for the study, countries selected are to be grouped and examined based on their stages of development namely, low income, lower-middle, upper-middle and high income according to World Bank's Income Group Classification. Most importantly, none of the past studies on EKC has applied the four income groups even though some have used other groupings such as developing countries (e.g. Narayan & Narayan, 2010), European Union (e.g. Bengochea-Morancho, Higon-Tamarit, & Martinez-Zarzoso, 2001) and industrialised countries (e.g. Canas, Ferrao, & Conceicao, 2003).

3.1.1 Theoretical Model I: EKC Hypothesis

Even though the focus of the study is on EKC, three additional variables namely institutional quality, foreign direct investment (FDI) and trade openness are considered as control variables in the analysis as the variables have been found influencing environmental quality. In other words, the study attempts to investigate the relationship between income and CO_2 emissions specifically with the presence of institutional quality, FDI and trade openness in the model. Thus, the discussion on the theoretical foundations connecting income, institutional quality, FDI and trade liberalisation with CO_2 emission is presented in this section.

The discussion begins by taking a look at the relationship between income and pollution, and then followed by the nexus between institutional quality and environmental quality. Next, the analysis on the linkage of FDI and foreign trade with environmental degradation will be carried out. Lastly, the estimable econometric specification will be constructed.

The relationship between income and pollution is commonly shown by the EKC Hypothesis. The hypothesis implies that as income increases initially at the early stage of development, pollution tends to grow rapidly because people concern about output more than the environment. However, in the later stage of development with high income level, people become more aware about the importance of clean environment, and thus pollution level decreases. This is in fact the logic behind the inverted U-shaped relationship between growth and pollution which is coined as the Environmental Kuznets Curve (EKC).

According to many researchers such as He and Wang (2012), Panayotou (1997), Tamazian and Rao (2009) and Torras and Boyce (1998), the quality of institutions plays an important role whereby it helps to reduce environmental degradation in countries. These researchers suggest that institutional factors such as law and order, control on corruption, a fairer distribution of income contribute positively to the EKC relations. With favourable institutional quality, countries can expect to enjoy improvements to the environment with higher future income levels. In other words, an improvement in institutional quality may lead to the flattening of EKC.

FDI has been considered as a main contributor for better economic performance. However, there is no universal agreement among researchers about the relationship between FDI and pollution. From the existing literature, it can be noticed that the impact of FDI on environmental degradation can be either positive or negative. For instance, Acharyya (2009), Grimes and Kentor (2003), Jorgenson (2007) and Xing and Kolstad (2002) find that FDI has a positive effect on CO_2 emissions. However, studies by List and Co (2000), Mielnik and Goldemberg (2002) and Perkins and Neumayer (2008) show that the inflow of FDI tends to improve environmental quality through the enhancement of energy efficiency of the host countries. According to Acharyya (2009), FDI inflow leads to both scale and composition effects in the short run. Due to scale effect, there will be an increase in pollutant emission as FDI stimulates more economic activities. On the other hand, the composition effect occurs when the share of dirty goods in GDP increases as price change favours their production. In contrast, income growth caused by FDI may lead to cleaner environment in the long run as people's demand moves toward cleaner products.

In addition, trade openness has been widely adopted as a control variable in the literature of EKC. Evidences [17] have shown that trade openness has either a positive or negative effect on the environmental quality. Grossman and Krueger (1991) and subsequently Antweiler et al. (2001) have given a thorough analysis of the association between trade openness and pollution. According to them, the impact of trade openness on pollution can be explained by three effects, i.e. scale, technique and composition effects.

[17] For instance, Ahmed and Long (2012), Chichilnisky (1994), Cole (2000), and Perkins and Neumayer (2009).

Scale effect is the likely increase in pollution due to economic growth caused by trade liberalisation that encourages exports. On the other hand, technique effect tends to reduce pollutant emissions in the sense that liberalised trade allows the imports of environmentally beneficial production technologies. Besides, international trade also fosters competition among domestic producers that in turn encourages them to adopt efficient technologies in order to reduce cost of production. Finally, the composition effect means the possible change in the composition of an economy resulting from continuous trade liberalisation. The composition of the economy alters as the country starts to specialise in industries in which it has a comparative advantage. Whether the composition effect will ultimately lead a rise or decrease in pollution relies on the industry in which a nation has comparative advantage in. A comparative advantage in clean industries, for example, will lead to a reduction in pollution level. In contrast, a comparative advantage in pollution intensive industries will result in a rise in pollutant level.

Following the above discussion, a model is estimated:

$$lc_{it} = \alpha_{it} + \alpha_1 lgdp_{it} + \alpha_2 lgdp2_{it} + \alpha_3 liq_{it} + \alpha_4 lfdi_{it} + \alpha_5 lto_{it} + \varepsilon_{it} \quad (3.1.1)$$

where lc_{it} refers to natural log of per capita carbon emissions, $lgdp_{it}$ represents the natural log of GDP per capita, $lgdp2_{it}$ is the natural log of GDP per capita in square, liq_{it} stands for the natural log of institutional quality, $lfdi_{it}$ is the natural log of foreign direct investment and lto_{it} is the natural log of trade openness ratio (i.e. the sum of total exports and imports of goods and services by the GDP) which acts as the proxy for foreign trade and ε_{it} is the regression error term. In the equation, subscripts i and t stand for countries and time periods respectively.

Looking at the model above, it is obvious that different values of income coefficient will result in varying relationships between per capita CO_2 and GDP per capita. For instance, if $\alpha_1 > 0$ and $\alpha_2 = 0$, then the relationship between the two variables will be linear. In the case where $\alpha_1 > 0$, $\alpha_2 < 0$, the theory of Environmental Kuznets Curve exists indicating that there is an inverted U-shaped relationship between income and pollution. The sign for α_3 is likely to be negative. However, it is difficult to predict the sign for both α_4 and α_5. They can be either positive or negative.

3.2 Theoretical Model II: CO_2 Emission, Institutional Quality and Income

In this study, it is assumed that Cobb-Douglas production function determines the output in each nation as follows:

$$Y_{it} = K^{\alpha}_{it} (A_{it}L_{it})^{1-\alpha} \qquad (3.2.1)$$

where Y_{it} is real income in country i at time t, K_{it} represents the physical capital stock in country i at time t, L_{it} reflects the stock of raw labour in country i at time t, and A_{it} is a labour-augmented factor showing the level of technology and efficiency in country i at time t[2].

The assumption is made that $\alpha<1$ which reflects decreasing returns to capital. Furthermore, the assumption is also made that raw labour and labour-augmenting technology are to change as below:

$$L_{it} = L_{i0}e^{n_i t} \quad (3.2.2)$$

$$A_{it} = A_{i0}e^{g_i t + P_{it}\theta_i} \quad (3.2.3)$$

where n_i is the exogenous rate of growth of the labour force in country i, g_i is the exogenous rate of technological progress in country i, P_{it} represents a vector of institutions, CO_2 emission and other factors that influence the level of technology and efficiency in country i at time t, while θ_i refers to a vector of coefficients associated to these variables.

From the above framework, it can be said that the state of labour-augmenting technology, i.e. variable A is affected by exogenous technological improvements (shown by g). In the mean time, it is also influenced by other factors such as the level of institutional quality and CO_2 emission. According to Demetriades and Law (2006), the proper functioning of institutions is a vital condition for productive labours in a country. If institutions are inefficient and ineffective, then labours will be wasted in handling rent-seeking activities. This view is supported by Nelson and Sampat (2001) and North (1990) who also suggest that poor institutions hamper growth by affecting productivity among labours. Individuals would tend to engage in unproductive activities with the absence of good institutions.

With increasing concerns over the negative impact of CO_2 emissions, both national climate policies and international efforts have started to provide incentives for the development of new emissions-reduction technologies which are cleaner and more efficient (Ghoniem, 2011; Weyant, 2011). Ghoniem (2011) suggests that the problems of increased CO_2 emissions and climate change can be addressed with the adoption of appropriate technologies.[18] In relation to this, the adoption of energy efficiency measures in industries have proven to contribute to some benefits for firms that include enhanced labour productivity. According to International Energy Agency (2014), efficiency improvements lead to higher labour productivity via reduced work absenteeism and less hours worked.

In such a neoclassical growth model, the level of institutional quality and CO_2 emission can only have a temporary impact on economic growth with dP_{it} / dt assuming at zero in the steady state. However, it can take a positive or negative value in transition. On the other hand, the value of P_i can be different from country to country in the steady state, which indicates that different countries can have varying level of per capita income. This means that different countries may end up with different steady states, relying on the

[18] Specifically, three approaches namely, enhancing efficiencies, using low carbon energy sources, and applying CO_2 capture and sequestration can be implemented to reduce CO_2 emissions.

degree of institutional development as well as the level of pollution in each of these countries.

Output per effective labour, i.e. Y/AL is constant but output per labour, i.e. Y/L increases at the exogenous rate g. Generally, output in effective labour terms evolves according to the following function:

$$Y_{it} / A_{it}L_{it} = (k_{it})^{\alpha}$$

In terms of (raw) labour, output evolves based on

$$Y_{it}/L_{it} = A_{it}(k_{it})^{\alpha} \qquad (3.2.4)$$

And let

$$y_{it} = (Y_{it}/L_{it})$$

Add logs to both sides of equation (3.2.4), the following equation will be obtained:

$$\ln y_{it} = \ln A_{it} + \alpha \ln k_{it}$$

By adding natural log to (3.2.3) and substitute it in $\ln y_{it} = \ln A_{it} + \alpha \ln k_{it}$, an equation is derived as follows:

$$\ln y_{it} = \ln A_0 + (1-\alpha)g_i t + (1-\alpha)\theta_i P_{it} + \alpha \ln k_{it} \qquad (3.2.5)$$

Equation (3.2.5) explains the evolution of output per labour (labour productivity), which is influenced by a vector of institutions and CO_2 emission (may vary over time), the exogenous growth rate of output and the level of physical capital.

In particular, Equation (3.2.5) is valid no matter whether it is within or beyond the steady state. Furthermore, another advantage of this equation is that it does not depend on the assumptions pertaining to the behaviour of saving, which may lead to unrealistic outcomes. Thus, equation (3.2.5) provides a good basis for estimation.

To estimate equation (3.2.5), a functional form for the vector P needs to be specified. Besides, an appropriate error term must be added. First of all, the simplest functional form which is linear can be constructed as follows:

$$\ln y_{it} = \ln A_0 + (1-\alpha)g_i t + (1-\alpha)\theta_{1i}P_{1it} + (1-\alpha)\theta_{2i}P_{2it} + \alpha \ln k_{it} + \varepsilon_{it} \qquad (3.2.6)$$

where P_1 represents CO_2 emission, P_2 indicates the overall quality of institutions and ε_{it} is an error term.

In addition, a non-linear functional form for P that includes a multiplicative term, indicating the interaction between CO_2 emission and institutions on growth can also be produced as follows:

$$\ln y_{it} = \ln A_0 + (1-\alpha)g_i t + (1-\alpha)\theta_{1i}P_{1it} + (1-\alpha)\theta_{2i}P_{2it} + (1-\alpha)\theta_{3i}(P_{1it}P_{2it}) + \alpha \ln k_{it} + \eta_{it} \qquad (3.2.7)$$

where η_{it} is a new error term.

The formation of the empirical models is based on both Equation (3.2.6) and (3.2.7) and the two equations can be rewritten respectively into reduced form as follows:

$$\ln y_{it} = b_{0i} + b_1 g_i t + b_{2i} INF_{it} + b_{3i} CO_{it} + b_{4i} IQ_{it} + b_{5i} X_{it} + b_{6i} FDI_{it} + b_{7i} \ln k_{it} + \varepsilon_{it} \quad (3.2.8)$$

$$\ln y_{it} = b_{0i} + b_1 g_i t + b_{2i} INF_{it} + b_{3i} CO_{it} + b_{4i} IQ_{it} + b_{5i} X_{it} + b_{6i} FDI_{it} + b_{7i} \ln k_{it} + b_{8i} CO_{it} IQ_{it} + \eta_{it} \quad (3.2.9)$$

where b's represent parameters to be estimated. INF, CO, IQ, X and FDI indicate inflation, CO_2 emissions, institutional quality, exports and foreign direct investment respectively.

The endogenous growth model proposed by Romer (1986) and Lucas (1988) highlights the importance of some control variables and proxies for macroeconomic environment in explaining growth. This is a siginificant advantage of endogenous growth model over the traditional approach. For instance, Jalilian, Kirkpatrick, and Parker (2006) emphasise the role of institutions in explaining the non-convergence of income levels among developed and developing countries. Thus, following the growth literature like Islam (1995), Mankiw, Romer, and Weil (1992), and Yao and Wei (2007) various important variables such as inflation, institutional factors, foreign direct investment and exports have been included in Equations 3.2.8 and 3.2.9.

In addition, an interactive term between CO_2 emissions and institutional quality is included in the model to investigate the role of institutional quality in influencing the effect of CO_2 emissions on income level. The inclusion of interaction term is drawn from two significant strands of existing literature that focus on the impact of CO_2 emissions on economic growth (e.g. Coondoo & Dinda, 2002; Hung & Shaw, 2006; Pearson, 1994) and the importance of institutional quality for economic growth (e.g. Keefer & Shirley, 2000; Lee & Kim, 2009; Siddiqui & Ahmed, 2013). The joint effect of CO_2 emissions and institutional quality on economic growth has recently begun to be studied (see Lau, Choong, & Eng, 2014). It is important to consider the interaction effect so that the overall effect of CO_2 emissions on economic growth can be captured. A positive interaction would mean that CO_2 emissions and institutional quality are complements in the growth process. This also indicates that the impact of CO_2 emissions on income is greater with better institutional quality. On the other hand, a negative interaction would imply that CO_2 emissions and institutions are substitutes in growth. This can be interpreted as the effect of CO_2 emissions on income declines as institutional quality improves.

3.3 The Selection of Dependent and Explanatory Variables: Reasoning

This section explains the rationale behind the choice of dependent and explanatory variables applied in the study.

3.3.1 Income

For the study, income which is measured by real GDP per capita is treated as the dependent variable in the growth model (for example, Adams, 2009; Awokuse, 2007; Whalley & Xin, 2010).In the mean time, real GDP per capita is also utilised as the indicator for income level in EKC model as shown in many previous studies (for example, Akbostanci, et al., 2009; He & Richard, 2010; Huang, Hwang, & Yang, 2008). The dataset for the indicator can be obtained from the World Development Indicators, World Bank.

In the case of EKC hypothesis testing, income is seen as the cause affecting CO_2 emission. If inverted U-shaped EKC curve does exist, then different stages of economic development will lead to either positive or negative impact on environmental degradation. Initially, as income increases, pollution will tend to increase as well due to scale effect. Later, when the economy experiences higher growth, a reduction in pollution will occur as people become more aware of the significance of clean environment. On the other hand, income also acts as a dependant variable whereby it may be influenced by numerous explanatory variables such as CO_2 emissions, inflation and institutional quality in the growth model.

3.3.2 CO_2 Emissions

In recent years, the problem of global warming is getting more and more severe. This, in turn, has led to much debate over the need to cut the emissions of greenhouse gases particularly CO_2. Many scientists support the view that CO_2 emissions has been the major cause for the increase in greenhouse gases that lead to global warming and climatic instability (IPCC, 1996). Besides, CO_2 is different from other types of pollutants in the sense that its effect is globalised instead of localised. Pollutants with localised impact affect only population at the manufacturing areas. This is not the case for CO_2. Since CO_2 emissions are the main contributor of greenhouse gases, it has been selected as the pollutant used in this study. CO_2 emissions will be used as both the dependent variable and explanatory variable in two separate models. In this study, the indicator for CO_2 emission applied is CO_2 emission per capita. This is the most frequently used indicator so far in cross country studies.[19]

There are two possible relations between CO_2 emission and income. First, income may be treated as both the cause and the cure for emission. In relation to this, many empirical studies have found an inverted-U curve of pollution relative to income which is known as “environmental Kuznets curve”. The curve indicates that emission tends to increase at lower levels of income and then reduce at higher levels of income. However, there are some exceptions to the usual inverted-U relationship in the empirical literature.

[19] Refer to Ezcurra (2007), Galeotti and Lanza (2005), Holtz-Eakin and Selden (1995) and Moomaw and Unruh (1997) for examples.

Some researchers found a positive linear relationship between income and emission. Further, the relationship may even take the interesting shape of "N". In such a case, CO_2 emission is considered as the dependent variable. For this study, it is expected that different patterns of relationship will be demonstrated for developed and developing countries since they are at different stages of development.

In the second relationship, CO_2 emission is considered as the cause whereas income is seen as the effect. This can be treated as a production relation where emission is an important input for the generation of income (Coondoo & Dinda, 2002). For the study, this is the case where CO_2 emission acts as an explanatory variable for economic performance. As emission decreases, it is likely that income will grow through enhanced efficiency and improved technological progress. Thus, emission is expected to cause a negative effect on income that will make the sign of CO_2 to be negative in this study.

3.3.3 Institutional Quality

In recent years, the studies on the role of institutions in fostering higher income have become a prominent line of research. This could be due to the realisation that all economic actors are affected by institutions (Gagliardi, 2008). Most of the researches find a positive relationship between institutional quality and economic performance. However, the direction of the causality between the two variables remains ambiguous.

There is a widespread consensus currently for taking institution quality as a main factor for determining economic performance. It is because good institutions may provide a favourable environment for cooperative solutions that bring about better economic performance. Besides, it is believed that even with good policies, many middle-income countries failed to catch up with the developed world due to poor institutional quality. However, some studies such as Glaeser, Porta, Lopez-de-Silanes, and Shleifer (2004) question the relevance of institutions in explaining growth since it is suggested that human capital is a more important factor affecting growth.

For this study, it is expected that the sign of the variable will be positive for growth model since many previous studies have found so. On the other hand, the sign for the relationship between institutional quality and CO_2 emissions is expected to be negative.

However, a major challenge for this study is to look for data that can adequately proxy the institutional quality. It is difficult to get direct measures of institutional quality. As a result, the available data provide only imperfect measures. In addition, according to Aidis, Estrin, and Mickiewicz (2009), researchers have yet come to a consensus on the single ideal variable that can be used to represent institutional quality. Institutional quality has been proxied using different variables from different sources such as International Country Risk Guide, EBRD Structural and Institutional Change Indicators and even variables constructed based on surveys (Efendic, Pugh, & Adnett, 2011).

The dataset used in this study for institutional quality factors is obtained from the International Country Risk Guide (ICRG) which is a monthly publication of Political Risk Services (PRS). According to Williams and Siddique (2008), ICRG is the most commonly used institutional data source today. In both the growth and EKC literature, institutional dataset from ICRG has been widely adopted as well.[20]

Another difficulty faced by the study concerns defining the concept of 'institutions'. According to researchers such as Chang (2007), Glaeser, La Porta, Lopez-De-Silanes, and Shleifer (2004) and Nelson and Sampat (2001), one fundamental challenge involved in the studies using institutional quality as a variable is that a widely accepted definition for institutions is yet to exist. In other words, there is no consensus among the researchers on how the term 'institutions' should be defined and different researchers have varying views on this. For instance, one of the earliest researches, Shubik (1975) defines 'institutions' as a complex set of "rules of the games". Later, Schotter (1981) explains the term as "the way the game is played". A common and widely used definition for institutions is proposed by North (1990) who states that

[20] For example, Barro (1996), Bhattacharyya (2009), Brunetti and Weder (1995), Chong and Calderon (2000), Knack and Keefer (1995), and Rigobon and Rodrik (2004).

institutions are "a set of rules, compliance procedures, and moral and ethical behavioural norms designed to constrain the behaviour of individuals in the interests of maximising the wealth or utility of principals" (p. 201). Another researcher has come out with an important definition for institutions as:

The sets of working rules that are used to determine who is eligible to make decisions in some arena, what actions are allowed and constrained, what aggregation rules will be used, what procedures must be followed, what information must or must not be provided, and what payoffs will be assigned to individuals dependent on their actions (Ostrom, 1990, p. 136).

In most cases, however, the definition of institutions will incorporate elements of rules or forms of conduct that aim to lower uncertainties, control the environment and reduce transaction costs (Menard & Shirley, 2005). In view of the fact that researchers do not have the agreement on the definition of 'institutions', it is impossible to produce a list of institutional variables that are desirable and essential for growth. Thus, any studies on the role of institutions would need to accept this limitation (Chang, 2007).

For the study, some common institutional variables from ICRG are adopted. In this study, the number of indicators used is restricted to five out of 12 Political Risk Ratings offered by ICRG.[21] The five variables include law and order, corruption, ethnic tensions, bureaucracy quality and democratic

[21] The 12 Political Risk components are as follows: Government Stability, Socioeconomic Conditions, Investment Profile, Internal Conflict, External Conflict, Corruption, Military in Politics, Religious Tensions, Law and Order, Ethnic Tensions, Democratic Accountability and Bureaucracy Quality.

accountability.[22] There are two main reasons for the choice. First, the data for other variables such as government stability and socioeconomic conditions are only available starting from May 2001. Second, the five selected indicators are more relevant and commonly used in explaining economic development and the shape of EKC as compared to others.

Most importantly, the five institutional variables are also selected based on the fact that they fulfil all the four institutional quality criteria, namely static efficiency, dynamic efficiency (or adaptability), predictability (or security) and legitimacy (Alonso & Garcimartin, 2013). First, law and order influences the institutional legitimacy as it enhances institution's capability to produce a normative framework that shapes agents' behaviour. Second, the degree of corruption affects institutional quality in the sense that it reduces security and in turn increases uncertainty in relation to human interaction. Higher corruption level leads to lower degree of safety and stability that increases transaction costs among agents. Democratic accountability is the third determinant for institutional quality. It is a factor that promotes static efficiency and adaptability. A democratic society (or a responsive government) is more likely to have sufficient resources allocated for providing good institutions. These institutions help to encourage behaviours that diminish social costs. Besides, democracy creates an environment that encourages a higher demand for quality institutions. The fourth variable, bureaucracy quality, is a factor related to dynamic efficiency. Strong bureaucracy minimises the revisions of policy when government changes. This reduces the

[22] The variables are adopted in Catrinescu et al. (2008) and Shimpalee and Breuer (2007) as well.

likelihood for rent-seeking activities and corruption. Lastly, ethnic tensions tend to fulfil the security criterion. It is because tensions within a country may result in conflicts, instability and insecurity.

However, the two main variables applied in this study are law and order, and corruption .[23]There are three main reasons for selecting law and order and corruption as the key variables. First, the maximum points awarded by ICRG to law and order (6 points) and corruption (6 points) are higher than bureaucratic quality (4 points) showing that the former two variables contribute more to the overall risk of a country as compared to the later. Second, law and order and corruption are more important comparatively in the sense that they are more frequently applied in the literature of growth and EKC. Third, the dataset on these two variables are more complete as compared to others.

In addition, a composite index that comprises of five variables is used to measure the overall institutional quality.[24] The composite index is obtained by, first converting the index value of bureaucratic quality from 0-4 to 0-6[25] and then averaging the index values of all the five institutional variables. The definitions of all the indicators are shown in Appendix A.

[23] ICRG law and order index is also applied in Alesina and Dollar (2000) and Bhattacharyya (2009). The corruption variable can be found in Aixala and Fabro (2008) and Catrinescu, Leon-Ledesma, Piracha, and Quillin (2008) too.
[24] For instance, Azman-Saini, Baharumshah, and Law (2010) and Catrinescu et al. (2008) also use composite index to measure institutional quality.
[25] The conversion is needed due to the fact that the index value for all other institutional variables used is from 0-6.

In general, based on the discussion above, "institutions" can be defined as "a set of political and social factors, and rules that govern the degree of political stability in a country" for this study. Thus, in this case, good "institutional quality" refers to "a phenomenon where a sufficient degree of political stability is achieved in the sense that it reduces transaction costs and increases efficiency, hence contributing to improved economic performance".

3.3.4 Foreign Direct Investment (FDI)

It seems that the openness of an economy tends to lead to better economic performance has been an undeniable fact. The openness of an economy can be divided into two dimensions: free trade in goods and services and free flow of capital stock across international borders (Marwah & Tavakoli, 2004) .Capital flows, particularly foreign direct investment, has become one of the main elements in globalisation. Thus, the focus of the study has been on the foreign direct investment (FDI).

Since the last two decades, FDI has increased tremendously surpassing the growth of world output and global trade. Despite the concentration of FDI still happens in the developed world, FDI to the developing countries has risen more than 12 times since 1980 (World Bank, 1999). According to World Bank (2006), FDI is made up of at least 60 percent of private capital flows to the developing nations. According to Yeyati, Panizza, and Stein (2007), FDI has risen by a factor of 10 worldwide with the doubling international trade. In believing that FDI stimulates economic growth, policy makers particularly from the developing world have been engaging in FDI promoting activities such as granting of subsidies to attract more foreign capital.

Theoretically, FDI seems to be more beneficial if compared to other types of financial flows because it enhances productivity growth via transfers of technologies and managerial expertise. In addition, it is also claimed that FDI is less vulnerable than other types of capital flows. In other words, sudden stops in flows are less likely in the case of FDI. In short, it is a safer kind of investment where long-term commitments to a country are involved.[26]

Empirical evidences have shown that FDI has positive, negative or even no effect on growth (Akinlo, 2004; Blomstrom, Marcellino, & Osbat, 2005; Buckley, Wang, & Clegg, 2007; Mah, 2010; Meyer, 2004; Schneider, 2005). However, many of the macroeconomic studies indicate a positive impact of FDI on growth. Thus, it is expected that the sign of this variable is most likely to be positive in this study. Nevertheless, the ultimate outcome depends very much on the local factors or absorptive capacities as well as development level of the host country. The endogenous growth literature has emphasized the role of local conditions such as institutional background in determining the growth enhancing effect of FDI across countries (Alfaro,

[26] Using data from the Mediterranean countries, Laurreti and Postiglione (2005) suggest that different types of private capital flows have varying impacts on economic growth.

Chanda, Kalmli-Ozean, & Sayek, 2004; Blomstrom, Lipsey, & Zejan, 1994; Herzer, Klasen, & Nowak-Lehmann, 2008).

3.3.5 Exports

Export expansion has been considered as a key factor leading to better economic performance due to the positive externalities it produces. For instance, those firms who engage in export activities may be able to enjoy certain benefits such as efficient resource allocation, economies of scale, greater capacity utilisation, improvement in technologies due to stiff foreign competition. Besides, more foreign exchange can be earned via exports, which encourages the imports of more capital goods. This will in turn help to stimulate economic growth. Some older researches have commented on the exports-led-growth hypothesis and claim that exports are not able to bring about growth. Nevertheless, in the present study, it is predicted that exports will cause a positive effect on growth based on the results of some more recent studies (Awokuse, 2007; Konya, 2006; Lean & Smyth, 2009).

3.3.6 Capital Stock

Capital stock is a common variable found in the growth literature. In this study, the dataset for capital is available from the database of World Bank.

The variable can have either positive or negative sign relying on the stage of production. At the initial stage of production, GDP per capita increases as capital increases. However, due to diminishing returns to capital, the GDP per capita will tend to reduce as capital increases given a specific increase in GDP.

Capital stock is derived from a standard perpetual inventory model as follows:

$$K_t = K_{t-1} + I_t - \delta K_{t-1}$$

where K_{t-1} refers to the stock of capital at time $t-1$, I_t is the flow of gross investment during period *t*, and δ is the rate at which the capital stock depreciates in period $t-1$. In this study, it is assumed that capital and output increase by the same rate for the estimation of initial stocks of private capital. The initial level of capital stock is produced using a depreciation rate of 6% and the average growth rate of the initial 5 years (1984-1988) (Demetriades & Law, 2006; Hall & Jones, 1999). According to Hall and Jones (1999), the initial capital stock can be obtained by using the formula below:

$$K_{t-1} = I_0 / (g + \delta)$$

where I_0 is the level of investment in the initial period, g represents the average growth rate of investment over the period considered, and δ refers to the rate of depreciation.

3.3.7 Inflation

Inflation is one of the most common variables in the macroeconomic environment affecting economic growth. To the structuralists, inflation is seen as an important factor leading to growth as shown by the Phillips Curve. However, many economists have challenged the validity of Phillips curve and suggested that inflation has a negative impact on economic growth (Burdekin , Denzau, Keil, Sitthyot, & Willett, 2000; Jung & Mashall, 1986; Risso & Carrera, 2009; Valdovinos, 2003). Thus, it is expected that the sign for this variable will be negative in the study.

3.4 A Review of Panel Unit Root Tests

Some extensions of unit root tests have been done since the earliest work of Dickey and Fuller (1979). The early literature on unit root tests focused on the univariate properties of macroeconomic time series. In recent years, much research efforts have been concentrated on examining the existence of a unit root in panel data. This is due to the reason that the existing unit root tests such as Dickey-Fuller (DF), augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) fail to differentiate the null hypothesis of unit root from its alternative of stationary due to lack of power while small sample sizes are used. As a result, the unit root null may not able to be rejected even when it is incorrect in the real fact.

Furthermore, univariate unit root tests may mistakenly identify a trend stationary process as a unit root, particularly when the stochastic portion of the trend stationary process has sufficient variance. This problem may arise with the usage of some variables such as GDP which are considered as trend stationary.

As a solution to the problem of lack of power, various researches have proposed the use of panel unit root tests as a way to add to the power based on a single time series (Frankel and Rose, 1996; MacDonald, 1996; Oh, 1996; Palm, Smeekes, and Urbain, 2011; Wu, 1996). Thus, many different forms of panel data models for both panel unit root and cointegration tests have been developed by econometricians since early 1990s.

However, three important and yet controversial issues have received considerable attention among researchers and have been extensively discussed in the literature of panel data models. The issues involved are namely, homogeneity testing, cross section dependence, and the problem of small sample bias. They are considered as crucial in the sense that the presence of any of these issues may lead to complication in estimation and inference in dynamic panel analysis.

In their research, Phillips and Sul (2003) have highlighted the implication of having these three problems in the estimation and regression. According to them, the problem of cross-section dependence can cause inefficient estimators and nuisance parameters. For instance, they find that the estimation of panel data regression with the existence of cross-section dependence leads to lack of efficiency in pooled OLS estimator as compared to single equation OLS. Further, such a spurious regression can result in invalidity of panel unit root tests in terms of its asymptotic properties.

For the issue of small sample bias in least squares regression of the coefficients in dynamic models, it is mentioned that the appearance of this problem in panel models can be more critical if compared to it is in univariate autoregressions according to Nickell (1981). Sometimes, the bias can be so serious that autoregressive coefficient falls entirely beyond the empirical distribution of the pooled OLS estimator of the coefficient.[27]

The third issue is regarding the assumption of homogeneity made by most researchers in dynamic panel models to take advantage of pooling in panel regression. However, such an assumption can lead to misleading results and inferences.

[27] An in-depth survey was done by Phillips and Sul (2003) pertaining to this bias.

To overcome the above mentioned econometric problems, numerous studies on panel unit root tests have been done. Among the researchers, Quah (1992) was the pioneer who suggested the testing of non-stationarity in a series by applying information from cross-sectional dimension using panel unit root tests. Besides, Levin and Lin (1992) have come out with a panel unit root test that takes a time trend as well as individual and time specific effect into consideration in which it has the same limiting normal distribution as in ADF test statistics. In addition, the researchers have developed six sub-models of this distribution.[28] The six sub-models are further estimated using OLS as a pooled regression. Due to the problems of heteroskedasticity and autocorrelation in the estimation, four remedial steps have been taken by Levin and Lin (1993) to enhance the efficiency of the estimators. First, subtract cross-section averages from the data to get rid of the impact of aggregate effects. Second, test each individual series with ADF test and normalize the residuals. Third, for each of individual series, maesure the ratio of long-run to short-run standard deviation and then compute the average ratio for the panel, and lastly, calculate the panel test statistic.

Unfortunately, the method applied above has a huge drawback in the sense that an assumption of all nations studied have a similar pattern or fixed effect across countries has been made. According to Maddala and Wu (1999), such assumption is illogical because different countries have varying macroeconomic policies and convergences of economic growth. Furthermore,

[28] Levin and Lin (1992) and Maddala and Wu (1999) explain the limiting normal distribution and the sub-models developed in a detailed manner.

Hsiao, Pesaran, and Tahmiscioglu (2002) point out that two issues need to be taken into account while using fixed effect dynamic panel data model, particularly with short time series dimension.

The two issues concerned are the individual-specific effect that can increase with the number of observations (T) in the cross section dimension (N) and the problem of initial value. They further conclude that the two issues may lead to the problem of 'incidental parameters'. To remedy the problem, the application of a transformed likelihood approach as the framework has been proposed. This approach has two obvious advantages. First, by maximising the transformed likelihood function, it can help to produce consistent estimators of structural parameters when N tends to infinity, regardless whether T is fixed or tends to infinity. Second, there exists a linear transformation that eliminates the individual effect, even though with the presence of incidental parameters.

In addition, a fully modified estimator for heterogenous panels was constructed by Pedroni (1996, 1997) in his studies. At the same time, asymptotic distributions for residual-based test of cointegration in the case of both homogenous and heterogeneous panels were developed. Furthermore, Choi (2002) proposes the application of instrumental variables (IV) estimation methods for an error component model to enhance the efficieny of estimator in estimation with the existence of heteroskedasticity. The author argues that the panel IV estimators are more superior as compared to both OLS and GLS estimators. It is because OLS and GLS estimators consist of stationary and difference stationary regressors which are inappropriate for statistical inference while regressors and errors are correlated.

However, the panel IV methods do not encounter such problems. The suggested estimators are namely, Within-IV-OLS, IV-GLS and Within-IV-GLS estimators. The asymptotic distributions of these estimators which are normally distributed are further derived for the error component model. According to the researcher, the normal distribution feature is vital in the sense that it can used to build standard tests with unknown limiting distributions. This feature in turn enables the panel IV estimators to solve the problems in relation to nearly non-stationary and endogenous regressors.

By referring to the average of Augmented Dickey-Fuller (Dickey & Fuller, 1979) statistics, Im, Pesaran, and Shin (2003) have introduced a new dynamic heterogeneous panel root test using mean group method. The authors claim that the suggested *t*-bar statistic has better size and higher power as compared to Levin and Lin (1992, 1993) tests by enabling for a higher degree of heterogeneity across individuals. Most importantly, the test statistic is able to compromise for the existence of serial correlation and heterogeneity problems in the estimations.

In the meantime, two test statistics for panel unit roots have been developed by Phillips and Sul (2003) to deal with the issues of small sample bias and cross section dependence. By basing on the framework proposed by Lehmann (1959) and Andrews (1993), a test which is median unbiased correction has been recommended by the researchers to overcome the problem of cross section dependence. This method can perform well in the panel models under the conditions where a simple dynamic structure is used and no additional regressors are needed. To overcome the problem of small sample biases, the authors suggested for the application of meta statistics. In their suggested median unbiased estimators (MUE), the assumptions of cross section dependence and homogeneity of autoregressive coefficients in cross sectional units are relaxed by Phillips and Sul (2003). At the same time, the researchers use a generalised common time effect (CTE) model which is the extension from study by Cermeno (1999). The purpose of applying CTE model is to address cross section dependence generally and allow tests of homogeneity restrictions on the dynamics that include unit root homogeneity.

In short, it can be said that the authors have made two important assumptions i.e. cross sectional independence and a homogenous AR(1) parameter for the tests suggested. Phillips and Sul (2003) argue that as a whole the proposed panel MUE is able to remedy bias and make variance smaller, accountable for cross section dependence in the presence of correct specification, no additional regressors, and Gaussianity.

According to Hurlin and Mignon (2004), the panel unit root tests can be grouped into two categories. First, it involves tests with the assumption of cross-sectional independence or the so-called first-generation panel unit root tests. For example, Levin and Lin (1992, 1993) develop tests for homogeneous panels while Im et al. (1997, 2003), Harris and Tzavalis (1999), Maddala and Wu (1999) and Choi (2001) come out with tests for heterogeneous panels.

Later, it was discovered that the assumption of cross-sectional independence is not realistic, and the existing tests have shown large size distortions with the existence of cross-sectional dependence (for example, O'Connell, 1998). As a result, the second category of tests that allows for cross-sectional dependence is developed and named the second generation panel unit root tests which include Bai and Ng (2004), Chang (2002), Choi (2002), Moon and Perron (2004), Phillips and Sul (2003), and Tylor and Sarno (1998).

In their recent study, Wang, Wang, Yang, and Li (2010) develop a unit root test for panel data that consists of great cross-sectional dependence. They attempt to generalise the nonlinear IV test suggested by Chang (2002) to cases in which there are some common characteristics in the panels. The test is carried out in two steps. The first step involves the elimination of cross-sectional dependence applying the approach of principal components as introduced in Bai and Ng (2004). Next, the treated data is tested using Chang's nonlinear IV test and the distribution of the test statistic is normal. By using a simulation study, the authors further conclude that their generalised nonlinear IV test is proven to be a well-performed test as compared to the existing tests.

Gengenbach, Palm, and Urbain (2010) have provided a detailed Monte Carlo comparison of various second- generation panel unit root tests. Besides, an analytical comparison of first- and second- generation panel unit root tests in the existence of factor structures can be found in Breitung and Das (2008).

3.5 Panel Unit Root Tests: Testing Approaches

Recently, much attention has been paid to the investigations of unit root in the panel test and thus various panel unit root tests have been developed. However, newly introduced panel unit root tests are found to be better in examining the null hypotheses of non-stationarity (Niu, Ding, Niu, Li & Luo, 2011). For the purpose of the present study, only three types of the panel root tests will be discussed and applied. These tests include Im, Pesaran, and Shin (IPS) (2003), and Fisher-type tests using ADF and PP tests (Maddala and Wu, 1999).[29]

[29] According to Levin and Lin's (1993) and O'Connell (1998), with the existence of cross-sectional dependence, panel unit root test may suffer from substantial size distortion. Besides, Harris and Tzavalis (1999) discover that small T yields Levin and Lin tests with low power and substantially undersized. Both Levin and Lin and Harris and Tzavalis tests have the weakness of not allowing for heterogeneity in the autoregressive coefficient, q. Thus, Im, Pesaran, and Shin (IPS) (2003), and Fisher-type tests using ADF and PP tests are applied to overcome the problem of heterogeneity that exists in the LL test. These test statistics have the advantages of ease in computation and, more importantly, without the assumption of homogeneity of coefficients in different countries.

Before presenting the details of each unit root test, a general theoretical framework of the panel unit root test will be first discussed.

Consider the following AR(1) process for panel data:

$$Z_{it} = \rho_i Z_{it-1} + X_{it} + \delta_i + \varepsilon_{it} \tag{3.5.1}$$

where $i = 1, 2, \ldots, N$ represent cross-section units or series that are observed over periods $t = 1, 2, \ldots, T_i$. The X_{it} indicates the exogenous variables in the model (include any fixed effects or individual trends), ρ_i are autoregressive coefficients, and the errors ε_{it} are assumed to be mutually independent idiosyncratic disturbance.

If $|\rho_i| < 1$, Z_i is said to be weakly (trend-) stationary, while if $|\rho_i| = 1$, then Z_i contains a unit root.

Two natural assumptions can be made about the ρ_i while testing the presence of the unit root by applying panel analysis. First, one can assume that $\rho_i = \rho$, which means that cross-sections contain of persistence parameters commonly. There are two tests obey this assumption, namely: Levin, *et al.* (2002) and Breitung (2000). Second, one can assume that ρ_i varies freely across cross- sections. The Im et al. (2003) and Fisher-type tests using ADF and PP tests follow this assumption.

3.5.1 Im, Pesaran and Shin (1997, 2003)

All the Im, Pesaran, and Shin, and the Fisher-ADF and PP tests enable for individual unit root processes. In such a case, ρ_i may vary across cross-sections. The tests share a common characteristic that is individual unit root tests can be combined to derive a panel-specific result. Im, Pesaran, and Shin (IPS) start by specifying a separate ADF regression for each cross section:

$$\Delta Z_{it} = \alpha Z_{it-1} + \sum_{j=1}^{pi} \beta_{ij} \Delta Z_{it-j} + X_{it}^{'} \delta + \varepsilon_{it} \quad (3.5.2)$$

The null hypothesis is shown as,

$$H_0 : \alpha_i = 0, \text{ for all } i. \quad (3.5.3)$$

while the alternative hypothesis can be given as:

$$H1: \begin{cases} \alpha i = 0 \; for \; i = 1,2 \ldots, N1 \\ \alpha i < 0 \; for \; i = N+1, N+2 \ldots, N \end{cases} \quad (3.5.4)$$

which means a non-zero fraction of the individual process is stationary.

After finding the separate ADF regressions, the average of the $t-$statistics for α_i from the individual ADF regressions, $t_{iT_i}(p_i)$:

$$\bar{t}_{NT} = \left(\sum_{i=1}^{N} t_{iT_i}(p_i)\right) / N \quad (3.5.5)$$

would then modified to come out with the desired test statistics.

If lag order is always zero ($p_i = 0$ for all i) , then simulated critical values for $\bar{t}_{NT}$ are given in the IPS paper for different numbers of cross sections N, series lengths T, and for test equations consisting of either intercepts, or intercepts and linear trends. In the event that the lag order in Equation (3.5.2) is not zero for some cross-sections, IPS shows that a properly standardized $\bar{t}_{NT}$ has an asymptotic standard normal distribution:

$$W\bar{t}_{NT} = \frac{\sqrt{N}\left(\bar{t}_{NT} - N^{-1}\sum_{i=1}^{N} E(t_{iT}(\bar{p}_i))\right)}{\sqrt{N^{-1}\sum_{i=1}^{N} var(t_{iT}(\bar{p}_i))}}$$

$$\rightarrow N(0,1) \qquad (3.5.6)$$

The expressions for the expected mean and variance of the ADF regression t- statistics, $E(\bar{t}_{iT}(p_i))$ and $Var(\bar{t}_{iT}(p_i))$, are given by IPS for various values of T and p differing test equation assumptions.

3.5.2 Fisher-Type Using ADF and PP Tests (Maddala and Wu, 1999; and Choi, 2001)

Alternatively, a modified approach to panel unit root tests has been introduced by Maddala and Wu (1999) and Choi (2001). They adopt results from Fisher's (1932) to produce tests that combine the *p*-values from individual unit root tests.

Let's treat π_i as the p-value from any individual unit root test for cross-section i, then under the null of unit root for all N cross-sections, and the asymptotic result can be obtained as follows:

$$-2\sum_{i=1}^{N} log\ (\pi_i) \rightarrow \chi^2_{2N} \quad (3.5.7)$$

Further, Choi shows that:

$$Z = \frac{1}{\sqrt{N}} \sum_{i=1}^{N} \Phi^{-1}(\pi_i) \rightarrow N\ (0,1) \quad (3.5.8)$$

where Φ^{-1} is the inverse of the standard normal cumulative distribution function. The test uses both the asymptotic χ^2 and standard normal statistics applying ADF and Phillips-Perron individual unit root tests, with similarity in null and alternative hypotheses. In the case of both Fisher tests, exogenous variables need to be specified for the test equation and one must decide to consider no exogenous regressors, individual constants (effects), or individual constant and trend terms. Furthermore, when ADF test statistics are used as the basis for the Fisher tests, the amount of lags applied in each cross-section ADF regression needs to be confirmed. However, the application of PP form of the test requires one to come out with a way to estimate f_0.

3.6 Generalised Method of Moments (GMM) Panel Data Analysis

This section provides a discussion on the adoption of Generalised Method of Moments as the method of estimation for the study.

3.6.1 Generalised Method of Moments (GMM) Panel Data Analysis: A Review

The presence of heteroskedastic errors of unknown functional form while estimating for linear regression models can be considered as a common problem found in the econometric literature. If the errors are heteroskedastic, then estimation done using methods such as OLS estimator is no longer efficient. In addition, according to Roy (2002), using estimators such as estimated generalised least squares (EGLS) without considering the problem of heteroskedasticity can lead to erroneous inferences. To overcome this problem, Delgado (1992), Hidalgo (1992), and Robinson (1987), recommend the application of nonparametric techniques since these methods are valid even if the functional form is mis-specified. On the other hand, Monte Carlo study can be carried out to make a comparison between the nonparametric EGLS estimators and some parametric estimators utilising both correct and incorrect forms of heteroskedasticity (Rilstones, 1991).

The study on the problem of heteroskedasticity in panel data estimations has been done aggressively by researchers until early 1990s. These researchers include Baltagi and Griffin (1988) and Li and Stengos (1994). Specifically, Baltagi and Griffin (1988) use parametric method to examine the existence of heteroskedasticity through the individual specific component, whereas Li and Stengos (1994) apply semi-parametric technique to test the same problem in the unit-time varying error component. However, these two studies found that both the suggested EGLS estimators and the true GLS estimator have similar asymptotic distribution. Furthermore, according to Li and Stengos (1994), the finite sample properties of their estimator have become adequate after carrying out a Monte Carlo study. In contrast, a large time component for the panel is needed for the test procedure recommemded by Baltagi and Griffin (1988).

In addition, a semiparametric estimation procedure with unknown functional form in the individual specific errors where a large time component is not required has been suggested by Roy (2002).[30] This study has led to a few important findings. First of all, several estimators such as the proposed EGLS estimator (EGLS), the iterative EGLS estimator (EGLSB),[31] the standard GLS estimator for a one-way error components model (GLSH), the within or fixed effects estimator (WITHIN)[32] and the OLS estimator (OLS) have proven to be efficient in the study. Next, the proposed estimator can be considered as efficient after conducting a Monte Carlo study. Lastly, all the estimators show similar pattern in terms of results for size performance where none of the techniques under-reject or over-reject significantly.

With the existence of heteroskedasticity, an efficient method that can be used to overcome the problem is known as the generalised method of moments (GMM) estimator. GMM is a general method used to estimate the

[30] A Monte Carlo experiment has been used by Roy (2002) to study the finite sample behaviour of the proposed estimators.
[31] Baltagi and Griffin (1988) develop the model with the assumption of homoskedastic error components.
[32] The details of the technique can be found in Baltagi (1985).

parameters of linear and nonlinear models, in which the parameters are chosen to provide the best fit to multiple equations, each of which sets a sample moment to zero (Stock & Watson, 2007).

Furthermore, while cross-country growth regressions are used, attention needs to be paid to two shortcomings that include endogeneity problems related to reverse causality and inconsistent estimates due to omission of relevant variables. Specifically, the endogeneity problem can be solved by applying initial or lagged regressors. Besides, the problem can be addressed using appropriate instrumental variables. On the other hand, by including a country specific effect, the issue of omitted variables can be overcome. With the use of panel data, the two econometric limitations stated above are able to be resolved partially.

To overcome the problems in a more thorough manner, however, require the application of two GMM estimators (Murshed & Serino, 2011). The first estimator is the first-differenced General Method of Moments (GMM) panel data estimator by Arellano and Bond (1991) that uses lagged levels of explanatory variables as instruments of the differenced variables. However, this technique has its own weakness as variables in levels are poor instruments for differenced variables. Due to this, the second method called system GMM estimator had been introduced by Arellano and Bover (1995) and Blundell and Bond (1998) to reduce the downward bias appeared in the previous method. In short, the new method not only produces more accurate coefficient estimates but also solves endogeneity problems.

3.6.2 Generalised Method of Moments (GMM)

Generally, cross section is said as the most commonly used estimation method for analysing the factors affecting economic growth, adopted traditionally by Mankiw et al. (1992). Some recent researches on economic growth also apply the same method (Glaeser, Porta, Lopez-de-Silanes, & Shleifer, 2004; Rodrik, Subramanian, & Trebbi, 2004). In these researches, an average was first obtained for the time-varying variables across time period under consideration. Then, a simple ordinary least square (OLS) had been used on the growth model. However, cross-section estimations do have some serious drawbacks. An omitted variable bias may happen due to the fact that the country-specific aspect of economic growth which is not taken into account in cross-section studies may have correlation with independent variables.

Besides, in order to obtain consistent estimates in cross section studies, it is a must for the explanatory variables to be exogenous. However, most of the explanatory variables employed in growth model are endogenous to the dependent variable. The problem can be overcome by using an instrumental variable approach, but it is often not easy to look for suitable instruments that are related with only explanatory variables and not the error terms (Lee & Kim, 2009).

Islam (1995) has successfully solved the problem of omitted variable bias and eliminated the time-invariant heterogeneity across countries using a fixed-effect panel estimation. Nevertheless, the problems of endogeneity and time-varying country effects remain with this method.

Caselli, Esquivel, and Lefort (1996) and Bond, Hoeffler, and Temple (2001) have applied the first-differenced generalised method of moments (GMM) to correct the problems of unobserved country heterogeneity, measurement error, omitted variable bias, and endogeneity. Further, Arellano and Bover (1995) and Blundell and Bond (1998) introduced system-GMM with the purpose of reducing small sample bias that features the first-differenced GMM applied to the growth equation in the study of Caselli et al. (1996).

Similarly, it has been decided that the best method to adopt for the study is the dynamic panel generalised methods of moments (GMM) techniques [33] first suggested by Holtz-Eakin, Newey, and Rosen (1988), and then further developed by Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998).

First of all, the impact of CO_2 emission on income can be expressed by the following time series model:

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[33] Refer to Arellano and Bond (1991), Arellano and Bover (1995), and Blundell and Bond (1998) for a full description of the method.

$$\Delta y_t = \alpha + \beta_1 \Delta CO_t + \beta_2 \Delta IQ_t + \beta_3 \Delta X_t + \varepsilon_t \quad (3.6.1)$$

where lower case letters show natural logarithms and Δ is the difference operator; *y* refers to natural log of real GDP per capita; *CO* is the natural log of CO_2 emission; *IQ* is the natural log of institutional quality; *X* represents some macroeconomic variables that are generally accepted to affect economic growth, and ε is the error term.

Equation (3.6.1) is applied to test the impact of CO_2 emission on income. However, for the purpose of testing how much does the impact of CO_2 emission on economic growth is influenced by institutional quality, then the interaction term between institutional quality and CO_2 emission needs to be included into Equation (3.6.1) as follows:

$$\Delta y_t = \alpha + \beta_1 \Delta CO_t + \beta_2 \Delta IQ_t + \beta_3 \Delta X_t + \beta_4 \Delta IQ * \Delta CO_t + \varepsilon_t \quad (3.6.2)$$

For the purpose of using GMM techniques, a dynamic panel data model can be derived from Equation (3.6.1) by adding the cross-sectional unit, *i* to it, as proposed by Arellano and Bond (1991):

$$\Delta y_{i,t} = \alpha + \beta_1 \Delta CO_{i,t} + \beta_2 \Delta IQ_{i,t} + \beta_3 \Delta X_{i,t} + \beta_4 \Delta IQ * \Delta CO_{i,t} + \tau_t + \eta_i + \varepsilon_{i,t} \quad (3.6.3)$$

or let $y_{i,t}$ be the logarithm of real GDP per capita growth rate in a country *i* at time *t*, then Equation (3.6.3) can be simplified as follows:

$$y_{i,t} - y_{i,t-1} = -\alpha \Delta y_{i,t-1} + \beta X_{i,t} + \tau_t + \eta_i + \varepsilon_{i,t} \quad (3.6.4)$$

where $y_{i,t} - y_{i,t-1} (= \Delta y_{i,t})$ is the growth rate in real per capita GDP; α is a parameter reflecting the convergence speed; $X_{i,t}$ is a set of explanatory variables, including CO_2 emission, institutional quality, exports, FDI and the interaction term, with associated parameter β ; η_i captures unobserved country-specific effects; τ_t is a period-specific effect common to all countries; and ε_{it} is disturbance term.

A strong autoregressive structure exists in the residual term based on the study by Arellano and Bond (1991) because annual data is used in the model. Due to this, business cycle effect may spread for greater than one year. The problem of business cycle can be dealt with by assuming that $\mu_{it} = \rho\mu_{it-1} + \varepsilon_{it}$, where $|\rho| < 1$, and ε_{it} is white noise disturbance term. After restructuring terms, Equation (3.6.4) has been transformed into:

$$y_{i,t} = (1-\alpha+\rho)y_{i,t} - \rho(1-\alpha)y_{i,t-2} + X_{i,t}\beta - \rho X_{i,t-1}\beta + \tau_t - \rho\tau_{t-1} + (1-\rho)\eta_i + \varepsilon_{i,t} \quad (3.6.5)$$

To overcome the problem of country-specific effects, first differences are required as proposed by Arellano and Bond (1991). Lagged levels of the regressors are used as instruments to solve the problem of the likely endogeneity of the explanatory variables (X) which is caused by correlation between lagged difference in per capita GDP with disturbance term as shown in Equation (3.6.5). Besides, Alonso-Borrego and Arellano (1999) and Blundell and Bond (1998) argue that the lagged levels of the variables become weak instruments when there is persistency in the explanatory variables. They mention that biased parameter estimation may occur due to the problem of weak instruments in small samples and large variance asymptotically. As a solution, an alternative system estimator combining the difference estimator with an estimator in levels has been proposed.

To overcome the problems, Arellano and Bond have introduced a few remedial steps. First of all, the time effect, τ_t needs to be eliminated by substracting from each variable its cross average in period t. Then, Equation (3.6.5) is transformed into first-differences to get rid of the country specific effects as follows:

$$\Delta y_{i,t} = (1-\alpha+\rho)\Delta y_{i,t-1} + \rho(1-\alpha)\Delta y_{i,t-2} + \Delta X_{i,t}\beta + \rho\Delta X_{i,t-1}\beta + \Delta\varepsilon_{i,t} \quad (3.6.6)$$

For the purpose of estimating Equation (3.6.6), it is proposed that the lagged levels of the endogenous variables to be used as instruments (Arellano & Bond, 1991). However, the use of lagged levels of the explanatory variables as instruments is valid only when we assume that there is no serial correlation in the disturbance term and the lag of the explanatory variables is weakly exogenous. If the second assumption is unable to be met, then both X_{it} and X_{it-1} would have a correlation with the disturbance term in Equation (3.6.6). In such a case, levels of variables lagged two years or above may need to be used as instruments.

Next, based on Arellano and Bond (1991), moment conditions are applied in determining the difference estimator as follows:

$$E[y_{i,t-s}(\varepsilon_{i,t} - \varepsilon_{i,t-1})] = 0 \text{ for } s \geq 2,\ t = 3,...,T \qquad (3.6.7)$$

$$E[X_{i,t-s}(\varepsilon_{i,t} - \varepsilon_{i,t-1})] = 0 \text{ for } s \geq 2,\ t = 3,...,T \qquad (3.6.8)$$

This step is required in the estimation since lagged differences of the explanatory variables are used as instruments in levels equation with the presence of two important assumptions, namely the error term is not correlated and correlation does not exist between difference in the explanatory variables and the error term despite association between the levels of the explanatory variables and the country-specific error term may occur.

As a result, the following stationarity properties are obtained:

$$E[y_{i,t+p}\eta_i] = E[y_{i,t+q}\eta_i] \text{ and } E[X_{i,t+p}\eta_i] = E[X_{i,t+q}\eta_i] \text{ for all } p \text{ and } q. \qquad (3.6.9)$$

Following Arellano and Bover (1995), the additional moment conditions for the regression in levels are shown as follows:

$$E[(y_{i,t-s} - y_{i,t-s-1})(\eta_i + \varepsilon_{i,t})] = 0 \text{ for } s = 1 \qquad (3.6.10)$$

$$E[(X_{i,t-s} - x_{i,t-s-1})(\eta_i + \varepsilon_{i,t})] = 0 \text{ for } s = 1 \qquad (3.6.11)$$

In short, by utilising the moment conditions in Equations (3.6.8), (3.6.9), (3.6.10) and (3.6.11), the GMM system estimator is derived. The validity of the instruments determines how consistent the GMM estimator would be. In the study, the Sargan test of over-identifying restrictions is used to examine the validity of the instruments.

It is worth highlighting that Halkos (2003) is the only researcher so far studying the relationship between environmental degradation and economic development using GMM estimation. In his study, the hypothesis of the inverted U-shaped EKC has been examined between sulphur emission and economic growth for 73 countries, but not CO_2 emission. Most recently, Tamazian and Rao (2010) uses GMM estimation to investigate the linkage between CO2 emission and economic development by considering also financial development and institutional quality. In this study, CO_2 emission is used as the proxy for pollution due to the fact it has been found to be the most important pollutant leading to global warming. According to World Bank (2007), CO_2 emission contributed to 58.8 percent of the greenhouse gases emitted.

Following Tamazian and Rao (2010), the benchmark specification for GMM estimation is applied to explain the impact of GDP on CO_2 emission as follows:

$$C_{it} = \alpha y_{i,t-1} + X_{i,t}\beta + v_i + \varepsilon_{it} \qquad (3.6.12)$$

where C_{it} denotes the dependent variable which is CO_2 emission per capita, $X_{i,t}$ is a vector of explanatory variables including income (Real GDP per capita), β refers to a vector of parameters to be estimated, v_i is the individual effect, and ε_{it} is the error term.

3.6.3 Advantages of GMM

The generalised method of moments (GMM) is applied in this study since it is an econometric technique which is more superior as compared to other panel data methodologies from two main aspects.

First, the introduction of a lagged dependent variable among the regressors that leads to temporal autocorrelation can cause problem in the model estimation. Due to the correlation between the lagged dependent variable and the error terms, some estimators like ordinary least squares (OLS) become biased and inconsistent. For instance, numerous studies such as Dinda (2009) and Dinda and Coondoo (2006) have been carried out to examine the panel causality between pollution and income by applying ordinary least squares (OLS) estimator , fixed effect estimator or random effect GLS estimator. However, these estimators are biased and inconsistent. Specifically, the inconsistency of fixed effect estimator relies on the time dimension (Nickell, 1981) and according to Anderson and Hsiao (1981), the GLS estimator is considered as biased in a dynamic model. To address the problems, Arellano and Bond (1991) have developed a two-step difference GMM method, in which the lags of explanatory variables in levels are used as instruments (Jaunky, 2011). The dynamic GMM is able to eliminate any country specific effect or any time-invariant variable by differencing the model. Further, it can also help to get rid of endogeneity problem caused by the correlation between the country specific effects and the right hand side variables (Baltagi, Demetriades, & Law, 2009).

Second, there are two common sources of bias namely, unobserved heterogeneity problem and the issue of endogenous explanatory variables in cross-sectional studies. Particularly, the cross-sectional studies basically make assumption that economic growth rate across countries is homogenous. In other words, the problem of cross sectional heterogeneity in initial level of economic development is not taken into account. Other than heterogeneity, endogeneity of explanatory variables such as foreign direct investment (FDI), may also lead to biased estimation since it is very difficult to assume all explanatory variables as exogenous. Therefore, in the presence of unobserved country specific effect and endogeneity problem, the application of GMM estimation recommended by Arellano and Bond (1991) is required where traditional methods such as ordinary least square (OLS) estimator or fixed effect estimators fail to provide an accurate estimation for a panel data model. To solve the problem of endogeneity among explanatory variables, GMM estimation involves getting more instruments employing the orthogonality conditions that exist between lagged values of right hand side regressors (Tamazian & Rao, 2010).

3.7 Data Sources

A group of developing and developed countries were chosen for the purpose of the study. Basically, the developed world and major emerging economies champion in total CO_2 emission. The developed countries are leading in terms of CO_2 emissions per capita. However, the growth rate of CO_2 emissions in certain developing countries is relatively high. This phenomenon of unequal contributions to the climatic problem has led to difficulty in designing effective and fair remedies in overcoming the problem of pollution by the international community.

Databases on various variables such as income, CO_2 emission, institutional quality, exports and FDI of both developed and developing countries from 1989-2008 are employed for the purpose of the study. The variable sources and definitions are shown in Appendix B. According to the World Bank, the world economies can be divided into three main categories, namely low-income, middle-income and high-income by looking at the estimates of gross national income (GNI) per capita. Specifically, low- and middle- income economies are called developing countries while high-income economies can be considered as developed countries.

The selection of countries and time period is strictly based on the availability of the data. Thus, as a result, 31 developed and 72 developing countries (with 16 low income, 29 lower-middle income and 27 upper-middle income) were chosen as shown in Appendix C to achieve the objectives of the study. Some missing data are dealt with by averaging the available data since it is found that country values do not change significantly over time.

CHAPTER 4

RESULTS AND INTERPRETATION:

ENVIRONMENTAL KUTZNETS CURVE (EKC) HYPOTHESIS IN DIFFERENT INCOME GROUPS

4.1 Introduction

The debate on whether environmental degradation will increase or decline as countries prosper continues to receive great attention in environmental research and policy. Many theoretical and empirical studies basically agree upon an inverted U-shaped link between economic growth and various types of pollutants such as CO_2, waste water discharge and sulphur dioxide emissions (see, for instance, Nasir & Rehman, 2011; Soytas, Sari, & Ewing, 2006) which is known as the Environmental Kuznets Curve (EKC). The inverted U-shaped link implies that initial economic development causes environmental degradation, but as income grows to a certain level – the "turning point", pollution decreases and a clean environment emerges in rich countries. If the inverted U-shaped nexus between income and pollution is true, then environmental quality will "naturally" improves as countries become richer and richer. However, the question on whether the EKC does exist in different income groups of countries based on World Bank Income Classification has yet to be answered. Thus, this study aims to discover the impact of economic growth on CO_2 emissions with the presence of institutional quality, trade openness and foreign direct investment in the developing and developed countries.

The chapter begins with the establishment of panel unit root properties of all variables used in the study by employing three panel unit root tests which include Levin et al. (2002) test, the Im et al. (2003) test and the ADF Fisher test introduced by Maddala and Wu (1999). Then, the subsequent section discusses the effects of economic growth on CO_2 emissions in accordance to different income groups. Specifically, this study investigates the existence of an inverted-U shaped EKC in both the developing and developed countries. It is followed by the examination of the role of institutional quality in influencing the shapes of EKC. In addition, this chapter also investigates the role of trade openness in explaining CO_2 emissions as proposed by Copeland and Taylor (2004), and Grossman and Krueger (1991). Further, a thorough analysis is done to check on the impact of foreign direct investment in affecting pollution in different income groups. In short, all the discussions done in this chapter are aimed to examine the stated hypothesis.

4.2 Panel Unit Root Tests

The objective of this section is to examine the panel unit root properties of all the variables used in the study. To serve this purpose, three panel unit root tests, namely Levin et al. (2002) test, the Im et al. (2003) test and the ADF Fisher test proposed by Maddala and Wu (1999) have been employed.

In relation to this, the test statistics for the natural log of the variables in level and in first difference have been generated. Table 4.1 to 4.5 demonstrate both the test statistics and the probability values for the panel unit root tests of all variables in all countries as well as in various income groups of countries. In each of the tables, the results are organised as follows. Column 2 presents the results for LLC test while the outcomes for IPS test are reported in column 3. Further, the results for ADF Fisher test are shown in the last column.

The results of the three panel unit root tests for all countries are reported in Table 4.1. It can be observed from the test statistics and the associated probability values of the three tests that all variables are panel non-stationary in level. For instance, the probability values of all variables in level are greater than 0.05 marginal level, indicating that the null hypothesis of non-stationary is not able to be rejected at the 5 percent significance level. However, while testing for unit root in first difference, it is discovered that the probability values obtained are less than 0.05 marginal level, implying that the null hypothesis of non-stationary is able to be rejected at 5 percent significance level.

Table 4.2 displays the results of panel unit root tests for high income countries. From the values of test statistics and probability, it can be concluded that all variables are panel non-stationary in level. For example, for the log levels of CO_2 emissions variable, the test statistics for the LLC test, IPS test and ADF Fisher test are revealed as 4.4350, -1.2564 and 71.2172 respectively. Besides, the associated probability values are all greater than 0.05 marginal level, showing that the null hypothesis of non-stationary cannot be rejected. However, when it comes to the first difference of all the variables, the probability values have become less than 0.05 marginal level, indicating that the null hypothesis of panel non-stationary can be rejected at 5 percent level of significance.

Similarly, it can be seen from the results shown in Table 4.3 that null hypothesis of a unit root is unable to be rejected at the level for all variables in upper middle income countries. The probability values, for example, are found to be more than 0.05 marginal level, suggesting that each of the series is panel non-stationary. Meanwhile, when employing the three unit root tests to the first difference of the variables, the numeric values show that the null hypothesis of all the series can be rejected at the significance level of 5 percent. This implies that all variables are stationary at first difference for upper middle income countries.

The same goes to lower middle income countries. The results of the unit root tests for lower middle income countries, as shown in Table 4.4, provide sufficient evidence for the existence of a unit root for all series in their levels, with all the values of probability more than 0.05 marginal level. However, when the first difference of the series is taken into consideration, the probability values obtained for all three tests are less than 0.05 marginal level. This suggests that all tests reject the null hypothesis of a unit root unanimously.

The results of the panel unit root test for low income countries are reported in Table 4.5. Again, the null hypothesis of non-stationary cannot be rejected in level for all variables in the sense that the probability values are larger than 0.05 marginal level.

Then, while testing for unit root in first difference, it is found that the null of unit root can be rejected, indicating that all the series are stationary.

In a nutshell, all the three tests suggest that the null hypothesis of non-stationary can only be rejected in first difference, but fail to be rejected in levels for all variables irrespective of income groups.

Table 4.1: Panel Unit Root Tests (All Countries)

Variable	LLC Test		IPS Test		ADF Fisher Test	
	Level	**First Difference**	**Level**	**First Difference**	**Level**	**First Difference**
CO2	-0.1790 (0.4290)	-39.9916** (0.0001)	0.3840 (0.6495)	-35.8493** (0.0001)	191.9730 (0.7500)	1573.1200** (0.0001)
GDP	-1.1085 (0.1338)	-16.8584** (0.0001)	5.0680 (0.9999)	-16.6273** (0.0001)	153.8990 (0.9974)	667.5230** (0.0001)
GDP2	-0.7888 (0.2151)	-16.5467** (0.0001)	-1.2643 (0.1031)	-16.2993** (0.0001)	152.2510 (0.9981)	657.5810** (0.0001)
FDI	3.7466 (0.9999)	-32.8466** (0.0001)	-0.4493 (0.3266)	-35.6493** (0.0001)	233.0800 (0.0947)	1379.5500** (0.0001)
TO	2.2715 (0.9884)	-37.2339** (0.0001)	-0.8764 (0.1904)	-31.6079** (0.0001)	222.2890 (0.2076)	1445.7400** (0.0001)
X	0.5506 (0.7090)	-23.2792** (0.0001)	4.0812 (0.9999)	-20.8731** (0.0001)	183.8720 (0.8640)	815.7830** (0.0001)
INF	76.1690 (0.9999)	-25.4032** (0.0001)	3.1281 (0.9991)	-29.9225** (0.0001)	184.3620 (0.8583)	1227.3400** (0.0001)
CS	7.0205 (0.9999)	-10.8021** (0.0001)	2.7997 (0.9974)	-14.7259** (0.0001)	105.4580 (0.9999)	638.6940** (0.0001)
LO	11.3148 (0.9999)	-77.3716** (0.0001)	2.5500 (0.9946)	-28.1281** (0.0001)	155.7220 (0.9214)	827.9370** (0.0001)
LOCO2	7.7830 (0.9999)	-29.7623** (0.0001)	-0.9838 (0.1626)	-26.7619** (0.0001)	240.2810 (0.0509)	1024.5900** (0.0001)
COR	3.4130 (0.9997)	-23.5541** (0.0001)	-1.0612 (0.1443)	-20.9646** (0.0001)	214.7710 (0.1703)	574.6730** (0.0001)
CORCO2	0.2933 (0.6154)	-37.2313** (0.0001)	-0.8303 (0.2032)	-32.5557** (0.0001)	192.1490 (0.7471)	1246.5400** (0.0001)
CI	5.0930 (0.9999)	-30.0677** (0.0001)	3.1888 (0.9993)	-23.6425** (0.0001)	149.0600 (0.9990)	1101.9500** (0.0001)
CICO2	5.7228 (0.9999)	-31.1491** (0.0001)	-0.7729 (0.2198)	-27.9231** (0.0001)	234.1070 (0.0871)	1103.7700** (0.0001)

Note:

Figures in parenthesis are the probability values
CO2= CO_2 Emissions
GDP= Real Gross Domestic Product Per Capita
GDP2= Square Term of Real Gross Domestic Product Per Capita
FDI= Foreign Direct Investment
TO= Trade Openness
X= Exports
INF= Inflation
CS= Capital Stock
LO= Law and Order
LOCO2= Interaction Term of Law and Order and CO_2 Emissions
COR= Corruption
CORCO2= Interaction Term of Corruption and CO_2 Emissions
CI= Composite Index of Institutional Quality
CICO2= Interaction Term of Composite Index and CO_2 Emissions

Table 4.2: Panel Unit Root Tests (High Income Countries)

Variable	LLC Test		IPS Test		ADF Fisher Test	
	Level	**First Difference**	**Level**	**First Difference**	**Level**	**First Difference**
CO2	4.4350 (0.9999)	-23.3455** (0.0001)	-1.2564 (0.1045)	-20.2991** (0.0001)	71.2172 (0.1979)	434.9350** (0.0001)
GDP	-0.0481 (0.4808)	-6.6642** (0.0001)	1.6808 (0.9536)	-7.0486** (0.0001)	56.1025 (0.6869)	156.4600** (0.0001)
GDP2	-0.0993 (0.4605)	-6.4804** (0.0001)	1.6353 (0.9490)	-6.9700** (0.0001)	56.2349 (0.6824)	155.0490** (0.0001)
FDI	1.9115 (0.9720)	-12.8308** (0.0001)	-0.8153 (0.2075)	-18.0596** (0.0001)	66.2718 (0.3319)	383.8830** (0.0001)
TO	-0.0909 (0.4638)	-13.8449** (0.0001)	-0.5765 (0.2821)	-11.8747** (0.0001)	69.5353 (0.2387)	247.0090** (0.0001)
X	1.7652 (0.9612)	-13.5532** (0.0001)	3.0133 (0.9987)	-10.7779** (0.0001)	44.5539 (0.9537)	233.7640** (0.0001)
INF	-0.4867 (0.3133)	-13.3955** (0.0001)	1.6764 (0.9532)	-13.8834** (0.0001)	63.3109 (0.4299)	296.4180** (0.0001)
CS	2.8990 (0.9981)	-6.4809** (0.0001)	3.7926 (0.9999)	-6.6191** (0.0001)	55.7243 (0.6996)	157.4740** (0.0001)
LO	7.0270 (0.9999)	-12.7870** (0.0001)	1.0852 (0.8611)	-8.7702** (0.0001)	33.5604 (0.8735)	127.5140** (0.0001)
LOCO2	3.0002 (0.9987)	-19.0672** (0.0001)	-0.5670 (0.2854)	-17.2161** (0.0001)	71.8722 (0.1834)	359.1120** (0.0001)
COR	-1.2533 (0.1051)	-11.5785** (0.0001)	-0.4893 (0.3123)	-10.3245** (0.0001)	55.2914 (0.5766)	121.7820** (0.0001)
CORCO2	-1.0725 (0.1418)	-21.7264** (0.0001)	-0.5785 (0.2815)	-19.3545** (0.0001)	71.2119 (0.1980)	406.5120** (0.0001)
CI	-0.4499 (0.3264)	-16.9784** (0.0001)	0.5306 (0.7022)	-14.5789** (0.0001)	50.8241 (0.8438)	299.4750** (0.0001)
CICO2	3.1546 (0.9992)	-18.9518** (0.0001)	-0.5352 (0.2962)	-17.0562** (0.0001)	63.3917 (0.4271)	362.7470** (0.0001)

Note:

Figures in parenthesis are the probability values
CO2= CO_2 Emissions
GDP= Real Gross Domestic Product Per Capita
GDP2= Square Term of Real Gross Domestic Product Per Capita
FDI= Foreign Direct Investment
TO= Trade Openness
X= Exports
INF= Inflation
CS= Capital Stock
LO= Law and Order
LOCO2= Interaction Term of Law and Order and CO_2 Emissions
COR= Corruption
CORCO2= Interaction Term of Corruption and CO_2 Emissions
CI= Composite Index of Institutional Quality
CICO2= Interaction Term of Composite Index and CO_2 Emissions

Table 4.3: Panel Unit Root Tests (Upper Middle Income Countries)

Variable	LLC Test		IPS Test		ADF Fisher Test	
	Level	**First Difference**	**Level**	**First Difference**	**Level**	**First Difference**
CO2	1.6299 (0.9484)	-17.3602** (0.0001)	0.3435 (0.6344)	-17.6576** (0.0001)	45.0583 (0.8018)	346.9700** (0.0001)
GDP	-0.6185 (0.2681)	-9.6064** (0.0001)	-0.4840 (0.3142)	-9.3264** (0.0001)	65.4360 (0.1369)	186.7620** (0.0001)
GDP2	-1.2934 (0.0979)	-9.5400** (0.0001)	0.2158 (0.5854)	-9.0596** (0.0001)	57.2626 (0.3550)	181.8900** (0.0001)
FDI	1.8520 (0.9680)	-18.9869** (0.0001)	-0.1350 (0.4463)	-18.3325** (0.0001)	48.7933 (0.6749)	357.4540** (0.0001)
TO	0.3361 (0.6316)	-16.8946** (0.0001)	-0.7873 (0.2156)	-15.6448** (0.0001)	66.6941 (0.1150)	307.3170** (0.0001)
X	0.6109 (0.7294)	-11.6868** (0.0001)	2.5475 (0.9946)	-9.8525** (0.0001)	49.6068 (0.6444)	196.6280** (0.0001)
INF	130.3830 (0.9999)	-20.0245** (0.0001)	0.5084 (0.6944)	-15.9153** (0.0001)	58.5307 (0.3127)	327.2770** (0.0001)
CS	4.9466 (0.9999)	-3.0072** (0.0013)	7.6617 (0.9999)	-4.1677** (0.0001)	22.2569 (0.9999)	113.4940** (0.0001)
LO	0.2168 (0.5858)	-63.1426** (0.0001)	2.2282 (0.9871)	-27.3438** (0.0001)	25.9937 (0.9990)	177.5580** (0.0001)
LOCO2	16.0390 (0.9999)	-12.9230** (0.0001)	0.8837 (0.8116)	-11.6122** (0.0001)	41.1707 (0.9003)	227.9190** (0.0001)
COR	0.9924 (0.8395)	-14.5303** (0.0001)	-1.2234 (0.1106)	-12.9236** (0.0001)	54.9216 (0.2289)	196.9890** (0.0001)
CORCO2	1.0689 (0.8574)	-18.9457** (0.0001)	-1.1285 (0.1296)	-16.1522** (0.0001)	63.6023 (0.1742)	316.7540** (0.0001)
CI	-0.5629 (0.2868)	-14.8831** (0.0001)	-0.8548 (0.1963)	-12.0002** (0.0001)	64.9068 (0.1470)	233.4350** (0.0001)
CICO2	-1.3791 (0.0839)	-14.7507** (0.0001)	-0.2999 (0.3821)	-12.8959** (0.0001)	59.7028 (0.2762)	255.4480** (0.0001)

Note:

Figures in parenthesis are the probability values
CO2= CO_2 Emissions
GDP= Real Gross Domestic Product Per Capita
GDP2= Square Term of Real Gross Domestic Product Per Capita
FDI= Foreign Direct Investment
TO= Trade Openness
X= Exports
INF= Inflation
CS= Capital Stock
LO= Law and Order
LOCO2= Interaction Term of Law and Order and CO_2 Emissions
COR= Corruption
CORCO2= Interaction Term of Corruption and CO_2 Emissions
CI= Composite Index of Institutional Quality
CICO2= Interaction Term of Composite Index and CO_2 Emissions

Table 4.4: Panel Unit Root Tests (Lower Middle Income Countries)

Variable	LLC Test		IPS Test		ADF Fisher Test	
	Level	**First Difference**	**Level**	**First Difference**	**Level**	**First Difference**
CO2	1.2317 (0.8910)	-24.7412** (0.0001)	1.6359 (0.9491)	-20.0545** (0.0001)	36.1549 (0.9891)	599.5960** (0.0001)
GDP	-1.0571 (0.1452)	-6.9132** (0.0001)	0.1805 (0.5716)	-6.9786** (0.0001)	73.2448 (0.0856)	162.6270** (0.0001)
GDP2	-0.8349 (0.2019)	-6.7081** (0.0001)	0.8659 (0.8067)	-6.7579** (0.0001)	65.9172 (0.2220)	159.5190** (0.0001)
FDI	2.6923 (0.9965)	-19.9806** (0.0001)	-0.7596 (0.2238)	-19.9111** (0.0001)	56.9408 (0.5147)	415.2320** (0.0001)
TO	4.8868 (0.9999)	-27.7983** (0.0001)	-1.6421 (0.0503)	-22.5162** (0.0001)	57.9648 (0.4766)	695.7500** (0.0001)
X	0.4621 (0.6780)	-10.8841** (0.0001)	3.0155 (0.9987)	-10.6804** (0.0001)	49.3046 (0.7849)	222.4200** (0.0001)
INF	3.9822 (0.9999)	-20.3975** (0.0001)	-1.2755 (0.1011)	-18.9752** (0.0001)	41.5367 (0.9495)	405.4200** (0.0001)
CS	2.1365 (0.9837)	-6.3733** (0.0001)	3.0738 (0.9989)	-9.4013** (0.0001)	62.8493 (0.3086)	201.4780** (0.0001)
LO	35.0833 (0.9999)	-6.6219** (0.0001)	0.6967 (0.7570)	-11.8341** (0.0001)	63.3460 (0.1800)	437.8150** (0.0001)
LOCO2	-1.5830 (0.0567)	-15.9703** (0.0001)	-0.6710 (0.2511)	-14.0927** (0.0001)	74.7078 (0.0689)	440.2710** (0.0001)
COR	-0.5528 (0.2902)	-10.4697** (0.0001)	-0.3758 (0.3535)	-9.7858** (0.0001)	60.7320 (0.3093)	156.2530** (0.0001)
CORCO2	-0.5528 (0.2902)	-10.4697** (0.0001)	-0.3758 (0.3535)	-9.7858** (0.0001)	60.7320 (0.3093)	156.2530** (0.0001)
CI	-0.8035 (0.2108)	-17.9292** (0.0001)	1.5862 (0.9436)	-12.1287** (0.0001)	48.3721 (0.8122)	451.8500** (0.0001)
CICO2	-1.1255 (0.1302)	-17.1915** (0.0001)	-0.9756 (0.1646)	-14.9724** (0.0001)	71.1335 (0.1153)	331.4670** (0.0001)

Note:

Figures in parenthesis are the probability values
CO2= CO_2 Emissions
GDP= Real Gross Domestic Product Per Capita
GDP2= Square Term of Real Gross Domestic Product Per Capita
FDI= Foreign Direct Investment
TO= Trade Openness
X= Exports
INF= Inflation
CS= Capital Stock
LO= Law and Order
LOCO2= Interaction Term of Law and Order and CO_2 Emissions
COR= Corruption
CORCO2= Interaction Term of Corruption and CO_2 Emissions
CI= Composite Index of Institutional Quality
CICO2= Interaction Term of Composite Index and CO_2 Emissions

Table 4.5: Panel Unit Root Tests (Low Income Countries)

Variable	LLC Test		IPS Test		ADF Fisher Test	
	Level	**First Difference**	**Level**	**First Difference**	**Level**	**First Difference**
CO2	1.6674 (0.9523)	-13.2585** (0.0001)	-0.5288 (0.2985)	-12.7615** (0.0001)	38.6293 (0.1950)	191.6220** (0.0001)
GDP	-0.8005 (0.2117)	-11.8335** (0.0001)	0.2039 (0.5808)	-10.8733** (0.0001)	48.8830 (0.1134)	161.6730** (0.0001)
GDP2	7.5904 (0.9999)	-11.6056** (0.0001)	4.4990 (0.9999)	-10.7904** (0.0001)	41.5346 (0.1206)	161.1220** (0.0001)
FDI	0.7385 (0.7699)	-13.3981** (0.0001)	-0.7080 (0.2395)	-14.7393** (0.0001)	38.6007 (0.1959)	222.9860** (0.0001)
TO	-1.3042 (0.0961)	-13.1503** (0.0001)	-1.2618 (0.1035)	-12.9888** (0.0001)	43.1754 (0.0897)	420.0600** (0.0001)
X	-0.2815 (0.3891)	-10.5318** (0.0001)	-1.2562 (0.1045)	-10.8078** (0.0001)	40.4071 (0.1463)	162.9720** (0.0001)
INF	-0.2292 (0.4094)	-7.4379** (0.0001)	1.4880 (0.9316)	-10.3861** (0.0001)	28.0858 (0.6651)	198.2240** (0.0001)
CS	2.0755 (0.9810)	-11.5717** (0.0001)	4.2754 (0.9999)	-10.3442** (0.0001)	15.6096 (0.9934)	166.2480** (0.0001)
LO	-0.9175 (0.1794)	-6.8126** (0.0001)	-1.2816 (0.1000)	-6.1543** (0.0001)	41.9496 (0.0723)	85.0507** (0.0001)
LOCO2	0.7802 (0.7824)	-11.3292** (0.0001)	-0.6448 (0.2595)	-10.0078** (0.0001)	41.4763 (0.1218)	183.3960** (0.0001)
COR	0.6246 (0.7339)	-10.5268** (0.0001)	-1.1070 (0.1341)	-8.9291** (0.0001)	40.1132 (0.1027)	99.6488** (0.0001)
CORCO2	1.8802 (0.9700)	-16.1883** (0.0001)	-1.4892 (0.0682)	-14.0969** (0.0001)	25.9208 (0.7671)	213.1370** (0.0001)
CI	6.3971 (0.9999)	-9.3302** (0.0001)	2.1855 (0.9856)	-7.7778** (0.0001)	15.4151 (0.9941)	117.1860** (0.0001)
CICO2	4.0311 (0.9999)	-10.3483** (0.0001)	-0.7136 (0.2377)	-10.2209** (0.0001)	36.3805 (0.2719)	154.1050** (0.0001)

Note:

Figures in parenthesis are the probability values
CO2= CO_2 Emissions
GDP= Real Gross Domestic Product Per Capita
GDP2= Square Term of Real Gross Domestic Product Per Capita
FDI= Foreign Direct Investment
TO= Trade Openness
X= Exports
INF= Inflation
CS= Capital Stock
LO= Law and Order
LOCO2= Interaction Term of Law and Order and CO_2 Emissions
COR= Corruption
CORCO2= Interaction Term of Corruption and CO_2 Emissions
CI= Composite Index of Institutional Quality
CICO2= Interaction Term of Composite Index and CO_2 Emissions

4.3 The Role of Institutional Quality in Affecting Economic Development on CO_2 Emissions In Developed and Developing Countries

All equations in Table 4.6 to Table 4.10 examine the impact of income on CO_2 emissions with the presence of institutional quality, trade openness and foreign direct investment in four different income groups (based on World Bank 2010 income classification, namely: high, upper-middle, lower middle and low income countries) and a panel of 103 countries using GMM technique. GMM estimator is used for the purpose of the study due to the fact that it is a useful technique to estimate the effects of income on CO_2 emissions in the sense that it helps to solve the problem of endogeneity involving these variables. The problem can be dealt with by taking the lagged values of the explanatory variables as instruments. The GMM methodology was initially introduced by Arellano and Bond (1991) and now commonly used in growth as well as EKC literature. For instance, see Halkos (2003), Huang, Hwang, and Yang (2008), Siddiqui and Ahmed (2013), and Tamazian and Rao (2010).

Further, Sargan test (or J-test for overidentifying restrictions) is applied to examine whether the instruments used in these regressions are valid. It is with the purpose of examining null hypothesis that there is no correlation between the instruments used and the residuals.[34] In all the equations, the Sargan test statistic shows that the null hypothesis, Ho: over-identifying restrictions are valid, cannot be rejected. In short, it is proven that the instrument variables applied in the GMM estimation in this study are appropriate.

[34] See Bowsher (2002) for further explanation.

Table 4.6 reports the results for a panel of 103 countries as the four categories of countries are grouped together. However, the estimated results for examining the existence of inverted U-shaped between economic growth and CO_2 emissions in four income groups are shown in Table 4.7 to Table 4.10.

4.3.1 The Validity of EKC Hypothesis in All Countries

By pooling all the 103 countries from the four income categories as a whole, it is found that the inverted U-shaped EKC does exist globally. From Table 4.6 (Equation 1), it is demonstrated that the coefficient for real GDP per capita is positive and statistically significant at 1 percent significance level. On the other hand, its squared term reports a significant negative coefficient value of -0.0434 with significance level at 1 percent. The results imply that all countries in the world are able to enjoy a reduction in CO_2 emissions due to growth.

Table 4.6: Environmental Kuznets Curve (EKC) Hypothesis in All Countries, 1989-2008

Variable	Equ. 1	Equ.2	Equ.3	Equ.4	Equ. 5	Equ. 6
$CO2_{t-1}$	0.5564*** (414.2999)	0.5265*** (229.5744)	0.3954*** (29.1190)	0.5719*** (147.0327)	0.5423*** (262.9870)	0.5853*** (241.5990)
GDP	0.8433*** (77.4344)	0.6062*** (39.0784)	1.6047*** (9.6552)	0.7640*** (38.1504)	0.8785*** (58.5527)	0.7280*** (33.3353)
GDP2	-0.0434*** (-65.4148)	-0.0264*** (-25.4290)	-0.0800*** (-6.0934)	-0.0390*** (-30.6871)	-0.0434*** (-50.9025)	-0.0381*** (-28.3815)
FDI		-0.0030*** (-43.5830)				
TO			0.0006*** (2.6346)			
LO				-0.0145*** (-14.9475)		
COR					0.0238*** (83.1518)	
CI						-0.0524*** (-41.4038)
Diagnostic Checking						
Sargan Test	0.4885	0.5481	0.2639	0.5454	0.5622	0.5455
Obs.	1854	1854	1854	1854	1854	1854

Notes:
Dependent variable is carbon dioxide emissions (metric tons per capita).
All the variables are taken in differences and lagged one period.
The Sargan Chi-square statistic tests the null hypothesis of no correlation between the instruments and residuals.
The figures in the parentheses are t-statistics.
*, ** and *** The coefficient is significant at 10%, 5% and 1% levels, respectively.

$CO2_{t-1}$= Initial CO_2 Emissions
GDP= Real Gross Domestic Product Per Capita
GDP2= Real Gross Domestic Product Per Capita Squared Term
FDI= Foreign Direct Investment
TO= Trade Openness
LO= Law and Order
COR= Corruption
CI= Composite Index of Institutional Quality
Different lag of dependent variable (CO_2) for instrumental variables are used in different models. The instrumental variables used are not listed due to different lag of CO_2 used. Lag structure is chosen based on Newey-West criteria.

As all countries are considered, it is found that FDI as an engine for growth has exhibited a negative impact on CO_2 emissions. Equation (2) in Table 4.6 shows that the coefficient of FDI for the panel of 103 countries on CO_2 emission is negative (-0.0030) and significant at 1 percent significance level. Generally, this result suggests that FDI has helped to enhance countries' ability to overcome pollution problem and led to the use of greener products and technologies that benefit everyone in a global context.

As all countries are combined as a whole, the result in Table 4.6, equation (3) indicates that trade has a positive effect on CO_2 emissions with coefficient of 0.0006 at 1 percent significance level. This means the higher percentage of trade in GDP, the greater the pollution will be. In short, international trade makes the earth that we are living in a more polluted place.

When it comes to the impact of institutional variables on CO_2 emissions, the results obtained are mixed, as portrayed in Table 4.6 from Equation (4) to (6). For law and order, the coefficient is found to be negative (-0.0145) and significant as shown by Equation (4), indicating that better law and order contribute to a reduction in CO_2 emissions in all countries under consideration. Similarly, the coefficient on the composite index of institutional quality is reported as negative (-0.0524) and significant at 1 percent significance level. This finding implies that the overall improvement in institutional quality will lead to a cleaner environment globally. The above results have proven the importance of institutional quality in contributing to an improvement in environmental quality and it is supported by many existing literature such as Carlsson and Lundstrom (2003), Deacon (1999), He and Wang (2012), and Tamazian and Rao (2009). However, corruption is discovered to have a negative relationship with CO_2 emissions, as the coefficient is positive (0.0238) and significant at 1 percent. The result suggests that as corruption worsens, pollution decreases in the world as a whole. According to Cole (2007) and Goel (2013), the possible impact of corruption on pollution depends very much on who acts first--the bribe giver (polluter) or the bribe taker (enforcing official). In this case, it is obvious that most of the bribe givers (polluters) act first by paying bribes even before emissions actually occur. By paying bribes to the enforcing officials, the polluters can have emissions not recorded or underreported. As a result, recorded CO_2 emissions will reduce as corruption increases.

In addition, it can also be noticed from Table 4.6, Equation (1) to Equation (6) that the shape of EKC remains as inverted-U with or without the inclusion of additional variables such as institutional quality, foreign direct investment and trade openness. This can be proven by the fact that the coefficient on GDP is positive and significant while the one on GDP square is negative and significant throughout all the equations. Thus, it is apparent that categorisation of countries into four income groups based on their respective income level may be helpful in leading to a better understanding of the relationship between income and CO_2 emissions, particularly on the shape of EKC.

4.3.2 The Validity of EKC Hypothesis in High Income Countries

Evidence from Equation (1), Table 4.7 reveals that the EKC hypothesis does exist in the case for high income countries. The coefficient of real GDP per capita is significant (at 1 percent significance level) and positive at the value of 2.1659. It means that at low income levels, CO_2 emissions will tend to increase as income rises. The sign of GDP2 is negative and statistically significant as expected. The coefficient value of -0.1083 of the squared term of the real income per capita indicates that after a threshold of income is reached, CO_2 emissions is expected to fall as income increases further. The result is consistent with existing literature such as Dijkgraaf and Vollebergh (1998), Galeotti, Lanza, and Pauli (2005), Jalil and Mahmud (2009), Kristrom and Lungren (2003), Pao and Tsai (2011), and Rezek and Rogers (2008) which suggest that CO_2 emissions increase with a rise in income initially, then reaches to a stabilization point and finally declines as economy grows further.

The existence of an inverted U-shaped EKC indicates that favourable impacts on the environmental quality of the composition and technique effects are stronger than the unfavourable scale effect in high income countries. The scale effects tend to dominate only at the early stages of economic development. In the later stages of development, these countries have experienced structural change in the economy that shift from energy-intensive economy towards technology-intensive service economy which is less polluting. In the mean time, the rich countries seem to have the ability to

Table 4.7: Environmental Kuznets Curve (EKC) Hypothesis in High Income Countries, 1989-2008

Variable	Equ. 1	Equ.2	Equ.3	Equ.4	Equ. 5	Equ. 6
$CO2_{t-1}$	0.3614*** (172.3539)	0.5021*** (29.2984)	0.5142*** (36.0693)	0.7353*** (22.9996)	0.7457*** (65.3529)	0.6901*** (20.4786)
GDP	2.1659*** (5.0624)	3.7635*** (4.0739)	3.5137*** (4.5775)	1.1596*** (3.5913)	3.1688*** (3.6571)	1.5057*** (8.1350)
GDP2	-0.1083*** (-4.8690)	-0.1939*** (-3.9841)	-0.1822*** (-4.5839)	-0.0639*** (-4.0195)	-0.1644*** (-3.7620)	-0.0823*** (-9.0845)
FDI		0.0004*** (4.7536)				
TO			0.0902*** (4.1727)			
LO				-0.0288*** (-20.4543)		
COR					-0.0670*** (-9.8763)	
CI						-0.0652*** (-15.6432)
Diagnostic Checking						
Sargan Test	0.5074	0.5278	0.7084	0.6072	0.5867	0.7101
Obs.	558	558	558	558	558	558

Notes:
Dependent variable is carbon dioxide emissions (metric tons per capita).
All the variables are taken in differences and lagged one period.
The Sargan Chi-square statistic tests the null hypothesis of no correlation between the instruments and residuals.
The figures in the parentheses are t-statistics.
*, ** and *** The coefficient is significant at 10%, 5% and 1% levels, respectively.
$CO2_{t-1}$= Initial CO_2 Emissions

GDP= Real Gross Domestic Product Per Capita
GDP2= Real Gross Domestic Product Per Capita Squared Term
FDI= Foreign Direct Investment
TO= Trade Openness LO= Law and Order
COR= Corruption
CI= Composite Index of Institutional Quality
Different lag of dependent variable (CO_2) for instrumental variables are used in different models. The instrumental variables used are not listed due to different lag of CO_2 used. Lag structure is chosen based on Newey-West criteria.

replace obsolete and dirty technologies with new and cleaner technologies that help to improve the environmental quality. Other than using cleaner technologies with the purpose of producing cleaner products and less polluted residual wastes, cleaning technologies such as air pollution control are also utilized to reduce the adverse environmentally effects of certain activities. In addition, more stringent environmental policies and efforts undertaken by the developed world in recent years due to increase awareness of the importance of environmental protection also provide an explanation for an inverted-U shaped income-CO_2 relationship in these countries.

The coefficient of FDI for high income countries is positive and significant (at 1 percent level) at the value of 0.0004. The result shows that a positive relationship is confirmed between FDI and CO_2 emissions in the developed countries. The findings are supported by some of the existing literature such as Acharyya (2009), Xing and Kolstad (2002), and Zhang (2011) who argue that FDI plays a vital role in deteriorating the environmental quality of the host countries. In this case, it is apparent that the adverse scale effect is more prominent than the composition effect resulting in an overall increase in CO_2 emissions. In other words, FDI-led greater economic activities have caused the deterioration of environmental degradation in high income countries.

Equation (3) of Table 4.7 reports that the coefficient of trade openness is positive (0.0902) and significant (at 1 percent significance level) indicating that foreign trade does lead to an increase in CO_2 emissions in the developed countries. This is consistent with the results obtained by past researchers such as Halicioglu

(2008), Sharma (2011), Shui and Harris (2006), and Suri and Chapman (1998), who suggest that trade openness has a positive effect on pollution. In addition, this finding is also consistent with the Hecksher-Ohlin trade theory that says trade causes more consumption and production of goods and services that may eventually lead to greater pollution. Interestingly, however, the result contradicts with some current literature like Yan and Yang (2010) who mention that free trade improves the environment in the developed world.

According to Antweiler et al. (2001), there are three ways namely, scale effect, composition effect and technique effect,[35] through which trade affects environmental quality. The scale effect and technique effect have a positive and negative influence respectively on CO_2 emissions. However, the composition effect that changes the economic structure due to trade may cause either a positive or negative impact on pollution. With trade, if a country possesses a comparative advantage in dirty industries, then pollution increases. However, if the comparative advantage is in clean industries, then the result will go reverse.

Two important points can be put forward to justify the result obtained. First, it is obvious that the positive trade-induced scale effect outweighs the negative trade-induced composition-technique effect. The scale effect might have led to an increase in CO_2 emissions due to expansion of economic activities. Both the composition and

[35] The scale effect means as more outputs are produced in the economy, pollution increases substantially. The composition effect is about change in structure of the economy. The technique effect means as rich countries have the ability to invest more on R&D, economic growth leads to technological progress that replaces obsolete and dirty technologies with newer and cleaner technologies, which reduces pollution.

technique effects are most likely negative in the sense that high income countries tend to specialise in cleaner industries and adopt greener technologies. Apparently, in this case, the benefits generated from the use of environmental friendly technologies (technique effect) and the change in structure of the economic activity (composition effect) are not able to be offset by the strong scale effect in high income countries. Second, as stated by Panayotou (2003), even though production patterns are getting cleaner over time in developed countries, however, their consumption patterns remain environmental unfriendly. In other words, trade might have contributed to greater pollution through in increase in consumption of goods and services in these countries.

The estimation results with regard to institutional variables are demonstrated in Equation (4) to (6). As expected, it is found that law and order has a negative impact on CO_2 emissions in high income countries. The value of coefficient on law and order is -0.0288 and it is significant at 1 percent significance level. Likewise, the coefficient on composite index of institutional quality is also negative (-0.0652) and significant, indicating that quality of institutions plays a vital role in improving environmental quality in developed countries. The results are in line with some previous studies such as Carlsson and Lundstrom (2003), Deacon (1999), He and Wang (2012), and Tamazian and Rao (2009) who claim that a reduction in CO_2 emissions can be achieved with proper institutional quality. On the other hand, the coefficient on corruption is negative (-0.0670) and statistically significant at 1 percent significance level as shown in Equation (6). The result provides support to the hypothesis that lower level of corruption leads to a better environmental quality, as mentioned by Leitao (2010) and Lopez and Mitra (2000). According to these researchers, a less corrupted nation is able to implement environmental laws in a smoother manner as compared to a more corrupted country. It is because the polluters will be more willing to comply with regulations as they realize government officials cannot be bought through bribes.

In general, it can be seen from Table 4.7 that the shape of EKC does not change with the inclusion of different additional regressors such as institutional variables. The EKC curve remains as inverted U-shaped in all equations (with negative GDP coefficient and positive for its squared term), suggesting that the threshold of income that enables a reduction in CO_2 emissions has been reached in high income countries, even without the inclusion of additional variables such as institutional quality.

4.3.3 The Validity of EKC Hypothesis in Upper Middle Income Countries

With respect to the results for upper middle income group from Equation (1) in Table 4.8, it is shown that the coefficient of real GDP per capita and its squared term are -0.4546 and 0.0401 respectively. It is also seen that both the real GDP per capita and its squared term are statistically significant at 1 percent level. Such results indicate that as real GDP per capita increases, environmental quality deteriorates in upper middle income countries. In other words, the inverted U-shaped EKC does not exist. Instead, there is a U-shaped relationship between income and CO2 emissions in upper middle income countries. This scenario may be due to the reasons that these developing nations are still undergoing a rapid industrialization process, a sharp

Table 4.8: Environmental Kuznets Curve (EKC) Hypothesis in Upper Middle Income Countries, 1989-2008

Variable	Equ. 1	Equ.2	Equ.3	Equ.4	Equ. 5	Equ. 6
$CO2_{t-1}$	0.6602*** (195.5694)	0.3035*** (25.4878)	0.0538*** (10.6184)	-0.0495*** (-9.3787)	-0.0864*** (-11.8971)	0.0826*** (13.0165)
GDP	-0.4546*** (-5.5798)	-0.8056*** (-3.4932)	1.9328*** (3.1398)	1.4187*** (5.5682)	2.3850*** (5.9495)	1.8826*** (6.8719)
GDP2	0.0401*** (7.1390)	0.0677*** (4.3902)	-0.0819** (-1.9715)	-0.0516*** (-3.0302)	-0.1113*** (-4.3452)	-0.0824*** (-4.6985)
FDI		0.0020** (2.2529)				
TO			-0.2860*** (-8.7919)			
LO				-0.0082** (-2.2190)		
COR					0.0274*** (7.7565)	
CI						0.0469*** (8.1150)
Diagnostic Checking						
Sargan Test	0.6742	0.7239	0.5404	0.5758	0.4846	0.5528
Obs.	486	486	486	486	486	486

Notes:
Dependent variable is carbon dioxide emissions (metric tons per capita).
All the variables are taken in differences and lagged one period.
The Sargan Chi-square statistic tests the null hypothesis of no correlation between the instruments and residuals.
The figures in the parentheses are t-statistics.
*, ** and *** The coefficient is significant at 10%, 5% and 1% levels, respectively.

$CO2_{t-1}$= Initial CO_2 Emissions
GDP= Real Gross Domestic Product Per Capita
GDP2= Real Gross Domestic Product Per Capita Squared Term
FDI= Foreign Direct Investment
TO= Trade Openness
LO= Law and Order
COR= Corruption
CI= Composite Index of Institutional Quality

Different lag of dependent variable (CO_2) for instrumental variables are used in different models. The instrumental variables used are not listed due to different lag of CO_2 used. Lag structure is chosen based on Newey-West criteria.

increase in the demand for transports and infrastructure as well as the modernisation in life styles (Sun, 2003).

Similar to high income group, the coefficient of FDI for the upper middle income countries is also found to be positive at 0.0020, and it is significant at 5 percent significance level. The result indicates that FDI and CO_2 emissions are positively linked in upper middle income countries. The findings are consistent with some of the previous studies (for instance, Acharyya, 2009; Xing & Kolstad, 2002; and Zhang, 2011) who claim that FDI tends to worsen the environmental quality of the host countries.

As shown by Equation (3) in Table 4.7, for trade openness, the coefficient is found to be negative (-0.2860) and significant at 1 percent significance level in upper middle income countries. The result implies that trade openness does contribute to a reduction in CO_2 emissions in these countries. It is consistent with the previous studies by Antweiler et al. (2001), Ferrantino (1997), and Rezek and Rogers (2008). The results can be explained by two reasons. First, the negative technique effect tends to have a stronger impact on CO_2 emissions if compared to the positive scale-composition effect. With trade liberalisation, it seems that the upper middle income countries have benefited substantially through the adoption of more modern and cleaner technologies which are transferred from the developed countries. However, the composition effect may be positive because trade has encouraged the production of "dirty" manufactured products in these countries. Second, trade openness has successfully created sufficient competitive pressure on upper middle income countries that encourages them to utilise their resources more efficiently. This causes a reduction in pollution.

Table 4.8, Equation (4) to (6) present the results for institutional variables in upper middle income countries. It is revealed that for law and order, the coefficient is negative (-0.0082) and statistically significant at 5 percent level of significance. The finding implies that as law and order improve, environmental quality will tend to improve as suggested by Carlsson and Lundstrom (2003), Deacon (1999), He and Wang (2012), and Tamazian and Rao (2009). In the case of corruption, the coefficient is found to be positive (0.0274) and significant, suggesting that as corruption worsens, CO_2 emissions reduce. This result is similar to those of Cole (2007) and Goel (2013) who suggest that by paying bribes to the enforcing officials, the polluters can have emissions not recorded or underreported. This phenomenon leads to a cut in pollution as corruption increases.

It should be highlighted that in the case of upper middle income countries, the shape of EKC does change due to the inclusion of additional variables. As shown in Equation (1), Table 4.8, a U-shaped relationship is found between income and CO_2 emissions with only GDP and its squared term on the right-hand side. Then, with the inclusion of trade openness and institutional variables as additional regressors, the EKC has turned into inverted U-shaped. This can be proven by the coefficients of GDP and GDP square which have become positive and negative respectively as indicated in Equation (3) to (6). The findings imply the significance of trade openness and institutional quality in helping to switch the shape of the EKC. With greater trade openness and better law and order in particular, CO_2 emissions decrease as income reaches a certain level in upper middle income countries

4.3.4 The Validity of EKC Hypothesis in Lower Middle Income Countries

Table 4.9 shows the results for lower middle income countries. The results suggest that real GDP per capita has a statistically significant (at 1 percent) negative effect on CO_2 emissions. However, the coefficient for the squared variable is positive and significant at the significance level of 1 percent. This means that as income rises initially, CO_2 emissions will tend to diminish, and as income grows further, CO_2 emissions will start to increase. In this case, a U-shaped relationship between income and CO_2 emissions is demonstrated which contradicts with the EKC hypothesis proposed by many of the existing literature. The reason why EKC hypothesis does not hold may be explained by the fact at the very beginning stage of economic development, lower middle income countries had less capital-intensive industries and poor transportation systems, and most importantly the use of energy is low. As mentioned by Nasir and Rehman (2011), EKC hypothesis is not valid for Pakistan (an example for lower middle income countries) because the industrial production only constitutes 25 percents of the GDP which is small enough to contribute to CO_2 emissions. However, the share of the service sector, a less polluting sector, is almost 50 percent. On the other hand, as income goes higher, environmental quality starts to deteriorate. One of the main reasons may be, with low production cost, these countries attract capital inflow that boosts the pace of industrialization process. This may lead to the production of large amount of CO_2 emissions.

Table 4.9: Environmental Kuznets Curve (EKC) Hypothesis in Lower Middle Income Countries, 1989-2008

Variable	Equ. 1	Equ.2	Equ.3	Equ.4	Equ.5	Equ.6
$CO2_{t-1}$	0.4865*** (20.3921)	0.6179*** (129.5644)	0.6343*** (162.8378)	0.3108*** (5.6523)	0.6320*** (93.5217)	0.6089*** (37.8816)
GDP	-4.7870*** (-3.6700)	1.6782*** (5.4061)	0.9540*** (3.1266)	10.4051*** (3.0389)	1.2612*** (2.5897)	3.2672*** (3.1691)
GDP2	0.3679*** (3.6940)	-0.0952*** (-4.0201)	-0.0409* (-1.6964)	-0.7394*** (-2.8340)	-0.0646* (-1.7121)	-0.2170*** (-2.6946)
FDI		-0.0049*** (-10.0056)				
TO			-0.0251*** (-2.7594)			
LO				-0.3391*** (-5.8974)		
COR					0.0092*** (2.8990)	
CI						-0.1216*** (-12.0355)
Diagnostic Checking						
Sargan Test	0.5543	0.6472	0.5796	0.7163	0.6731	0.5556
Obs.	522	522	522	522	522	522

Notes:
Dependent variable is carbon dioxide emissions (metric tons per capita).
All the variables are taken in differences and lagged one period.
The Sargan Chi-square statistic tests the null hypothesis of no correlation between the instruments and residuals.
The figures in the parentheses are t-statistics.
*, ** and *** The coefficient is significant at 10%, 5% and 1% levels, respectively.
$CO2_{t-1}$= Initial CO_2 Emissions

GDP= Real Gross Domestic Product Per Capita
GDP2= Real Gross Domestic Product Per Capita Squared Term
FDI= Foreign Direct Investment
TO= Trade Openness
LO= Law and Order
COR= Corruption
CI= Composite Index of Institutional Quality

Different lag of dependent variable (CO_2) for instrumental variables are used in different models. The instrumental variables used are not listed due to different lag of CO_2 used. Lag structure is chosen based on Newey-West criteria.

The lower middle group demonstrates a negative link between FDI and CO_2 emission as shown by equation (2) in Table 4.9. The value of coefficient on FDI is recorded at -0.0049 and it is statistically significant at 1 percent significance level, suggesting that capital inflows do contribute to a cut in CO_2 emissions in lower middle income countries. It follows that the results are consistent with the previous studies on this subject by List and Co (2000) and Perkins and Neumayer (2008) who suggest that FDI causes host countries to be more energy efficient and helps to reduce CO_2 emissions. The improvement in energy efficiency is possible because FDI encourages the utilisation of more advanced and cleaner technologies that might have resulted in a decrease in CO_2 emissions.

In the case of trade openness, it is discovered that the coefficient is negative (-0.0251) and significant at 1 percent significance level, as shown by Equation (3) in Table 4.9. The result is consistent with the previous studies such as Antweiler et al. (2001), Ferrantino (1997), and Rezek and Rogers (2008) who suggest that trade openness leads to a reduction in CO_2 emissions in the developing countries.

Furthermore, Equations (4) to (6) report the results for the impact of various institutional variables on CO_2 emissions. As predicted, this is noticed that law and order has a negative effect on CO_2 emissions. The coefficient is negative (-0.3391) and statistically significant at 1 percent significance level, proposing that law and order is a vital factor that can lead to a reduction in CO_2 emissions in lower middle income countries. The same goes to the overall institutional quality that is found to be negatively related to CO_2 emissions. The findings are consistent with some existing literature like Carlsson and Lundstrom (2003), Deacon (1999), He and Wang (2012), and Tamazian and Rao (2009) who stress the importance of institutional quality in reducing CO_2 emissions. The coefficient on corruption, however, is found to be positive (0.0092) and statistically significant at 1 percent level. The result shows that the greater the corruption, the cleaner the environment, which is in line with findings of some researchers such as Cole (2007) and Goel (2013). These researchers suggest that as corruption increases, pollution reduces because the polluters can have emissions not recorded or underreported by paying bribes to the enforcing officials.

Similar to upper middle income countries, the lower middle income countries do experience a change in the shape of EKC due to the inclusion of additional variables. This is true in the case of all additional variables considered. With the inclusion of only GDP and GDP square on the right-hand side, the link between income and CO_2 emissions is discovered to be U-shaped. Then, by considering foreign direct investment, trade openness and institutional variables as additional regressors, the EKC has turned out to be inverted U-shaped, as shown in Equation (2) to (6) (Table 4.9). The results portray the importance of foreign direct investment, trade openness and institutional quality in contributing to an improvement in environmental quality in lower middle income nations.

4.3.5 The Validity of EKC Hypothesis in Low Income Countries

For the low income group, it is discovered that, like the lower middle income group, follows a U-shaped relationship between real GDP per capita and CO_2 emissions. From Equation (1) (Table 4.10), the coefficient for real GDP is found to be -2.8698 and it is statistically significant at 1 percent significance level. Its squared term is also significant with a coefficient of 0.3111. Similar to lower middle income group, the same argument for the U-shaped EKC may apply to the low income countries. At the early stage of development, less dirty industries exist in these countries. Economic growth relies more on non-polluting sectors such as agricultural activities and natural resource based industries. As income increases further, environmental degradation worsens as more and more factories are built particularly by foreign investors who take advantage of the low labour costs in these poorest countries.

Similar to lower middle income group, low income countries also show a negative relationship between FDI and CO_2 emission as portrayed by equation (2) in Table 4.10. The coefficient of FDI is negative (-0.0014) and statistically significant at 1 percent significance level. The results are in line with some existing literature such as List and Co (2000) and Perkins and Neumayer (2008) who suggest that FDI encourages the use of more advanced and cleaner technologies in the host countries that in turn help to reduce CO_2 emissions.

Table 4.10: Environmental Kuznets Curve (EKC) Hypothesis in Low Income Countries, 1989-2008

Variable	Equ. 1	Equ.2	Equ.3	Equ.4	Equ. 5	Equ. 6
$CO2_{t-1}$	0.4202*** (25.4807)	0.3880*** (5.5627)	0.3553*** (12.7447)	0.5383*** (41.4146)	0.2497*** (4.2468)	0.4543*** (5.8275)
GDP	-2.8698*** (-5.4964)	-5.6062* (-1.8104)	-6.0330*** (-6.1132)	-2.3741*** (-4.0890)	-7.1373*** (-3.1112)	-3.0304*** (-4.4857)
GDP2	0.3111*** (5.3375)	0.5570* (1.8739)	0.6250*** (6.7420)	0.2546*** (4.0096)	0.7179*** (3.7391)	0.3356*** (4.4860)
FDI		-0.0014*** (-3.3381)				
TO			-0.1427*** (-4.9378)			
LO				0.0270*** (4.7637)		
COR					0.0323*** (3.5434)	
CI						-0.0109 (-0.3701)
Diagnostic Checking						
Sargan Test	0.5108	0.6334	0.7374	0.4958	0.7263	0.7605
Obs.	288	288	288	288	288	288

Notes:
Dependent variable is carbon dioxide emissions (metric tons per capita).
All the variables are taken in differences and lagged one period.
The Sargan Chi-square statistic tests the null hypothesis of no correlation between the instruments and residuals.
The figures in the parentheses are t-statistics.
*, ** and *** The coefficient is significant at 10%, 5% and 1% levels, respectively.
$CO2_{t-1}$= Initial CO_2 Emissions

GDP= Real Gross Domestic Product Per Capita
GDP2= Real Gross Domestic Product Per Capita Squared Term
FDI= Foreign Direct Investment
TO= Trade Openness
LO= Law and Order
COR= Corruption
CI= Composite Index of Institutional Quality

Different lag of dependent variable (CO_2) for instrumental variables are used in different models. The instrumental variables used are not listed due to different lag of CO_2 used. Lag structure is chosen based on Newey-West criteria.

As expected, the coefficient on trade openness is negative (-0.1427) and significant at 1 percent significance level. This indicates that trade openness has a negative impact on CO_2 emissions in low income countries.

From the previous sections, it can be noticed that the same scenario also exists in upper middle and lower middle income groups. The results imply that trade openness leads to a cut in CO_2 emissions in the developing world, as supported by some previous studies such as Antweiler et al. (2001), Ferrantino (1997), and Rezek and Rogers (2008). A reduction in CO_2 emissions as a result of trade liberalisation may be due to two main reasons. First, the negative technique effect outweighs the positive scale-composition effect. Second, competitive pressure created by trade openness has successfully encouraged less developed countries to utilise their resources more efficiently.

As demonstrated in Table 4.10, Equation (4) to (6), the coefficient on law and order is positive (0.0270) and statistically significant indicating that this institutional variable does not contribute to a reduction in CO_2 emissions. Instead, CO_2 emissions increase with the presence of law and order. This may be due to the fact that even though rules and regulation in controlling pollution do exist in low income countries, there is still lack of compliance and enforcement for these legislations as suggested by Zhang (2008). Similar to other developing countries, low income group has a positive coefficient for corruption. Equation (5) shows that the value of coefficient is 0.0323 and significant, proposing that as these poorest countries become more corrupted, CO_2 emissions decline. The result is supported by Cole (2007) and Goel

(2013) who suggest that greater corruption leads to lower pollution as bribes paid to the enforcing officials by the polluters enable them to have emissions not recorded or underreported. Besides, the coefficient for composite index of institutional quality shown in Equation (6) is found to be not significant, though negative at the value of -0.0109. This result indicates that due to improper governance, institutions fail to contribute to a decline in CO_2 emissions in low income countries.

In addition, all equations in Table 4.10 show that the EKC remains as U-shaped even with the inclusion of additional regressors. In this case, the coefficient on GDP is negative and significant in all equations. In the mean time, the squared term of GDP is recorded to have positive and significant coefficient in all equations as well. The findings imply that all the additional variables considered, namely foreign direct investment, trade openness and the three institutional indicators are not able to contribute to a significant reduction in CO_2 emissions in low income countries. This can be proven by the fact that in these countries environmental degradation worsens as income increases, as portrayed by the U-shaped EKC.

From the above discussion, it can be concluded that only high income countries have experienced improvement in environmental quality along the path of economic growth. In the developing countries, however, pollution increases rapidly and sooner or later it will become a major concern that requires remedial actions. As income reaches a threshold, there will be a tendency to devote more resources to environmental protection based on the inverted U-shaped EKC. Alternatively, it is possible for the developing countries namely, upper middle, lower middle, and low income countries to achieve environmental improvement in the future through structural change, policy change or technological change, or combination of these measures.

4.4 Conclusion and Discussions

This chapter intends to investigate the impact of income on CO_2 emissions with the presence of three additional variables, namely institutional quality, trade openness and foreign direct investment, in various groups of countries based on World Bank Income Classification for the period 1989-2008 using GMM technique. In particular, the existence of the inverted U-shaped relationship between income and CO_2 emissions has been examined. Several principal results emerge from this chapter.

From the empirical results, it can be concluded that the inverted U-shaped relationship between real GDP per capita and CO_2 emissions is confirmed for high income countries indicating that environmental quality may improve “automatically” as income increases. The inverted U-shaped relationship is in line with some previous studies and this shape is expected. As countries get richer, they experience structural change in the economy towards less polluting sectors and at the same time adopt cleaner technologies that help to reduce pollution. For the developing (upper middle income, lower middle income and low income) countries, a U-shaped link exists between income and CO_2 emissions implying that CO_2 emissions may continue to increase as income grows higher. Specifically, at very low levels of income, CO_2

emissions tends to decline and as income increases to a certain level, CO_2 emissions start to rise due to industrialization in these countries. On the other hand, empirical results obtained by considering all the 103 countries as a group confirms the validity of an inverted U-shaped EKC.

Looking at the influence of foreign direct investment on the income-pollution nexus, the results obviously show that a positive relationship between foreign direct investment and CO_2 emissions does exist in both the high and upper middle income countries. This result is in line with the notion that foreign direct investment encourages more economic activities that lead to environmental degradation (Grimes & Kentor, 2003; Jorgenson, 2007). In this case, the negative composition effect is too weak to outweigh the adverse scale effect that causes the CO_2 emissions to increase with more foreign direct investment.

A totally different picture is shown in the lower middle and low income countries whereby foreign direct investment has a negative effect on CO2 emissions. In these countries, foreign direct investment stimulates the adoption of greener technologies that might have led to rapid improvement in energy efficiency and in turn causes a reduction in CO_2 emissions. An investigation using global data produces the same result. This result is consistent with many of the previous studies such as Mielnik and Goldemberg (2002), and Perkins and Neumayer (2008). Most importantly, in the case of lower middle income countries, foreign direct investment has caused a change in the shape of EKC. As a result of higher foreign direct investment in these countries, the EKC switches from U-shaped to inverted U-shaped.

Moreover, the estimation results on the impact of trade openness on CO_2 emissions suggest that there is a positive and significant relationship between the two variables in high income countries and the panel of 103 countries. This phenomenon occurs due to the fact that positive scale effect remains stronger than the negative composition and technique effects. Besides, international trade induces higher consumption on goods and services that might have led to an increase in CO2 emissions. On the other hand, however, the analysis for the developing countries indicates that trade openness has a negative and significant impact on CO_2 emissions. Based on the result, it is apparent that upper middle, lower middle, and low income countries are benefited significantly by the transfer of cleaner technologies from developed countries. Besides, CO_2 emissions decrease because the developing countries have been forced to utilize their resources more efficiently in response to stiff competition created by international trade. The findings also indicate that the pollution haven hypothesis does not help to explain the inverted U-shaped relationship between economic growth and CO_2 emissions in high income countries. It should be stressed that the role of trade openness in reducing CO_2 emissions is particularly important in upper middle and lower middle income countries. In these countries, trade openness has not only led to a reduction in CO_2 emissions, but a change in the shape of EKC from “U” to “inverted U”.

In addition, the estimated coefficients on law and order are negative and statistically significant in all income groups except low income countries. The results suggest that law and order is an important factor contributing to a cleaner environment in most of the countries in the world. It is particularly essential in upper middle and lower middle income groups in the sense that law and order has helped to turn the EKC into inverted U shaped from the initial U-shaped. In the case of low income group, however, a positive relationship between the variables can be explained by weak compliance and enforcement of environmental laws in these countries.

The impact of corruption on CO_2 emissions is seen to be negative only in the case of high income countries. This indicates that as corruption reduces, CO_2 emissions decreases as well. However, in other income groups, the coefficient on corruption is positive and significant, implying that greater corruption leads to a cut in CO_2 emissions. This result obtained is rather interesting since it seems that corruption can serve as a remedy for pollution in developing countries. In reality, however, the actual amount of CO_2 emissions might not have reduced. Rather, there is merely an underestimation of CO_2 emissions due to underreporting.

As the composite index of institutional quality is considered, a negative and significant relationship is found between the overall institutional quality and CO_2 emissions in most of the income groups. The results are supported by many existing literature such as Deacon (1999), He and Wang (2012), and Tamazian and Rao (2009). Exception occurs in the low income group where the coefficient is revealed as negative, but not significant. Most importantly, the overall institutional quality plays a vital role in controlling pollution especially in upper middle and lower middle income countries in which the shape of EKC has become inverted U with the inclusion of the variable.

In a nutshell, the results obtained in this chapter are mixed depending on the stage of economic development of the group of countries under consideration. This may imply that different public policies are required in different groups of countries in tackling environmental problems without retarding economic growth.

CHAPTER 5

RESULTS AND INTERPRETATION:

CO2 EMISSIONS, INSTITUTIONAL QUALITY AND INCOME IN DIFFERENT INCOME GROUPS

5.1 Introduction

In this chapter, the estimated panel results using GMM estimator for the relationship between CO_2 emissions, institutional quality and income are reported. CO_2 is incorporated into the growth model following previous researches such as Dinda and Coondoo (2006) and Lean and Smyth (2010). On the other hand, institutional quality is considered due to the fact that many researchers like Knack and Keefer (1995) and Lee and Kim (2009) have proposed the importance of institutions in affecting growth. However, different institutional variables may not have equal importance in influencing GDP depending on how develop a country is.[36] Further, the role of institutional quality in cutting the environmental cost of economic growth has been discussed in studies like Panayotou (1997) and Tamazian and Rao (2009).

Bearing in mind that the quality of institutions may influence income via CO_2 emissions, this chapter therefore constructs different measures for institutional quality and then examine the empirical relationship between these institutional quality indicators, CO_2 emissions and income. Three important measures for institutional quality have been considered namely law and order, corruption and institutional

[36] For examples, see Aixala and Fabro (2008) and Lee and Kim (2009).

composite index (comprises of law and order, corruption, ethnic tensions, democratic accountability, and bureaucratic quality).[37]

The first section of the chapter investigates the CO_2 emissions, institutional quality, and income association for all countries in the world. The following sections demonstrate the analysis of CO_2 emissions-institutional quality-income nexus for different income groups, namely high income, upper middle income, lower middle income and low income countries based on World Bank 2010 income classification. In these sections, the findings of different income groups are also compared.

For this study, the GMM technique is employed to deal with the problem of simultaneous causation between CO_2 emissions-income and institutional quality-income by considering the lagged levels of the explanatory variables as instruments. This technique was first introduced by Arellano and Bond (1991). Later, it has been widely used in the growth literature. Examples include Lee and Kim (2009), Siddiqui and Admed (2013), and Soukiazis and Antunes (2011). Sargan test is used to examine the validity of the instruments used in all the regressions. The test aims to check whether the instruments used are correlated with the residuals. The results of Sargan test shown in all equations from Table 5.1 to 5.5 indicate that there is no rejection for the null hypothesis of no over-identifying restrictions. Thus, the instruments used are appropriate for all the estimations.

[37] See Chapter 3, Section 3.3.3 for the calculation of index.

The selection of countries and period for the purpose of this study is exclusively based on data availability.

5.2 CO_2 Emissions, Institutional Quality and Income for All Countries, 1989-2008

The results of the relationship between CO_2 emissions, institutional quality and income for all 103 countries with varied growth experiences are summarized in Table 5.1. Equation (1) in Table 5.1 shows the impact of CO_2 emissions on income without taking institutional quality into account. The results of the influence of different institutional factors, namely law and order, corruption and composite index on income for all countries are presented in Equations (2), (3) and (4) respectively. On the other hand, Equations (5), (6) and (7) include the interaction term between each of the institutional indicators and CO_2 emissions.

As shown in Table 5.1, capital stock has a positive impact on income with the coefficients estimated as 0.1346, 4.1157, 1.6126, 4.4455, 0.7598 and 2.0846 respectively from Equations (1) to (7), except Equation (4). All the positive coefficients are significant at the level of 1 percent. The positive capital-growth nexus indicates that the world as a whole is experiencing

Table 5.1: CO_2 Emissions, Institutional Quality and Income in All Countries, 1989-2008

Variable	**Excluding Institutional Quality**	**LO**		**COR**		**CI**	
	Equ. 1	**Equ. 2**	**Equ. 5**	**Equ. 3**	**Equ. 6**	**Equ.4**	**Equ.7**
GDP_{t-1}	0.4112*** (336.5317)	0.3243*** (12.0109)	0.3392*** (195.5430)	0.2981*** (144.1263)	0.3327*** (154.9542)	0.3422*** (174.0344)	0.2445*** (152.9556)
CS	0.1346*** (2.8156)	4.1157*** (7.8573)	1.6126*** (24.6570)	4.4455*** (83.5097)	0.7598*** (7.9269)	-0.0934 (-0.6899)	2.0846*** (63.8680)
CO2	-0.1436** (-2.1707)	2.7664 (1.5000)	-26.3279*** (-78.9101)	5.4189*** (35.2227)	-12.9416*** (-54.7234)	-1.9883*** (-11.5971)	-29.5551*** (-69.6959)
X	-0.0669** (-2.0939)	-7.0784*** (-9.2858)	-1.2314*** (-21.1569)	-4.4518*** (-72.9006)	0.2185*** (3.2639)	1.0964*** (11.7616)	-1.8987*** (-31.8506)
FDI	0.0529*** (84.4207)	-0.0967*** (-4.5781)	0.0343*** (39.8417)	0.0322*** (32.0664)	0.0506*** (56.0576)	0.0411*** (69.2947)	0.0430*** (47.5523)
INF	-0.0002*** (-5.4301)	0.0003 (1.4659)	-0.0007*** (-17.4674)	0.0001*** (7.9786)	-0.0001* (-1.9193)	-0.0006*** (-7.1414)	-0.0001 (-0.6184)
LO		0.2961 (0.4582)	-9.3221*** (-95.4538)				
COR				-0.4730*** (-10.6763)	-4.1644*** (-51.8196)		
CI						3.2546*** (36.0716)	-10.3412*** (-57.5446))
LO x CO2			23.9850***				

			(73.0882)				
COR x CO2					10.0403*** (39.4019)		
CI x CO2							32.3412*** (76.6239)
Diagnostic Checking							
Sargan test (p-value)	0.5091	0.4671	0.5447	0.5913	0.5417	0.6591	0.5493
Obs.	1854	1854	1854	1854	1854	1854	1854

Notes:
Dependent variable is real GDP per capita.
All the variables are taken in differences and lagged one period.
The Sargan Chi-square statistic tests the null hypothesis of no correlation between the instruments and residuals.
The figures in the parentheses are t-statistics.
*, ** and *** The coefficient is significant at 10%, 5% and 1% levels, respectively.
GDP_{t-1} = Initial Real Gross Domestic Product Per Capita
CS= Capital Stock
CO2= CO_2 Emissions
X= Exports
FDI= Foreign Direct Investment
INF= Inflation
LO= Law and Order
COR= Corruption
CI= Composite Index of Institutional Quality
LOCO2= Interaction Term of Law and Order and CO_2 Emissions
CORCO2= Interaction Term of Corruption and CO_2 Emissions
CICO2= Interaction Term of Composite Index and CO_2 Emissions
Different lag of dependent variable (GDP) for instrumental variables are used in different models. The instrumental variables used are not listed due to different lag of GDP used. Lag structure is chosen based on Newey-West criteria.

increasing returns to capital. As capital stock increases, the per capita real GDP will tend to rise as well.

Inflation (growth rate of CPI) is reported to have a negative impact on income basically. Equations (1) to (7) demonstrate that the estimated coefficients for inflation are negative and statistically significant at usual level of significance in most of the equations. This finding has the implication that macroeconomic instability may deter countries around the world from prospering in terms of higher economic growth.

The effect of CO_2 emissions on income by considering the panel of 103 countries is also reported in Table 5.1. From the table, it can be seen that CO_2 emissions are negatively linked with income. Besides Equations (2) and (3), the coefficients for CO_2 emissions in other specifications report a negative value regardless of whether the interactive term is included. For example, the coefficients of CO_2 emissions in Equations (1), (4), (5), (6) and (7) are all negative and significant at the standard level of significance with the values of -0.1436, -1.9883, -26.3279, -12.9416, and -29.5551 respectively. The results demonstrate that as CO_2 emissions increase globally, the GDP in countries all over the world will be affected.

There are two possible explanations that can be put forward in figuring out the phenomenon according to the existing literature. First, some researchers like Borhan et al. (2011), Lean and Smyth (2010), and Stern et al. (1996) argue that if the issue of environmental degradation is not taken care of, then negative externalities brought about by pollution problem may reduce human health and the quality of industrial equipment, and in turn lead to a decline in productivity in the long run. This is the reason why income declines as environmental degradation deteriorates.

Another reason that can help to explain the negative relationship between CO_2 emissions and income has been pointed by Coondoo and Dinda (2002) who suggest that as income reaches a threshold level, decreasing emissions would be associated with income growth. Some specific conditions are required for the realisation of this relationship. For countries to experience low emission with high growth, they may need to undergo a structural change from emission-intensive manufacturing to less emission- intensive services in the economy. Another condition under which the negative relationship may emerge is that the conventional fossil fuel is replaced with less polluting energy resources, even if a country's economy continues to be manufacturing-intensive. Since there are two possible explanations for the negative link between CO_2 emissions and income, thus studies based on the categorization of countries according to their stage of development may help to provide a clearer picture of whether higher emissions lead to lower growth or lower emissions cause better economic growth in countries around the world.

Table 5.1 also presents the results for the exports and income nexus in all countries. It is found that generally exports have a negative impact on income, with the value of coefficients shown as negative and statistically significant at the standard usual level of significance in most of the regressions. For instance, the estimated coefficients for exports are reported as -0.0669, -7.0784 and -4.4518 from Equations

(1) to (3). The result is consistent with findings by some of the researchers who have been criticizing the exports-led-growth hypothesis while supporting the inward oriented trade policies. For example, researchers who do not agree with the export-led-growth hypothesis include, Bahmani–Oskooee and Economidou (2009), Emmanuel (1972), Jaffe (1985), Prebisch (1962) and Reppas and Christopoulos (2005). They argue that exports, in fact, lead to slower growth due to a few reasons. The reasons given include worsening of terms of trade and inefficient demand for the products particularly of less developed countries (Prebisch, 1962), unequal exchange (Emmanuel, 1972) as well as unpredictable global market (Jaffe, 1985).

In contrary to the negative relationship between exports and income, foreign direct investment is found to have a positive impact on income, as revealed in Table 5.1. As expected, the results indicate that foreign direct investment exerts a positive effect on income at 1 percent level of significance in all regressions with or without the inclusion of interaction term, except Equation (2). This outcome is in line with empirical evidence that generally suggests a positive link between the two variables. According to researchers like De Mello (1997), Whalley and Xin (2010), and Yao and Wei (2006), foreign direct investment is able to promote economic growth as it encourages capital accumulation and knowledge spillovers. Furthermore, it is believed that foreign direct investment can foster growth by improving existing stock of knowledge through training and education as well as introducing new management practices in the host countries.

As institutional variables are included in the model, it is found that the estimated coefficient for law and order is positive (0.2961) but statistically insignificant as shown in Equation (2). However, the value of coefficient for corruption is negative (-0.4730) and significant at 1 percent level of significance as reported in Equation (3). Furthermore, Equation (4) shows that the coefficient for composite index of institutional quality turns out to be positive (3.2546) and 1 percent statistically significant. Based on the results, it can be concluded that the impact of institutional composite index on income is the greatest, followed by degree of corruption.

The insignificant though positive coefficient for law and order indicates that the variable does not contribute to a higher income in the case of all countries. This also implies that law and order may exist in all countries around the world, but the authorities in some countries, especially developing countries have failed to implement, monitor, and enforce the rules and regulations set in a proper manner as mentioned by Zhang (2008).

Besides, the negative coefficient for corruption indicates that as corruption worsens, income in all countries would tend to improve [38] as supported by researchers such as Bardhan (1997), Kaufmann (1997), and Knack and Keefer (1995). This is due to the fact that corruption may help in "greasing the wheels" of inflexible bureaucracies in the economy by enhancing their efficiency. Besides, according to Aidt (2003), corruption tends to improve allocative efficiency by stimulating competition for scarce government resources.

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[38] The corruption index is ranging from 0 to 6. 0 indicates highest level of corruption.

Moreover, the overall institutional quality which is measured by the composite index affects the income of countries around the world positively. This finding demonstrates that as the overall institutional quality improves around the world, real GDP per capita increases, which is consistent with theory. For example, existing literature such as Knack and Keefer (1995), North (1990), and Rodrik (2000) emphasize the importance of institutional quality in stimulating growth. They argue that improvement in institutional quality can help to create a favourable environment leading to the possibility of cooperative solutions that in turn causes economic growth.

To examine the role of institutional quality in affecting the relationship between CO_2 emissions and income, the interactive terms[39] between each of the institutional variables and CO_2 emissions are considered, as presented in Equations (5) to (7) of Table 5.1. With the inclusion of interactive terms, it can be seen from the table that the coefficient for CO_2 emissions remains as negative and statistically significant (at 1 percent level of significance) at the value of -26.3279, -12.9416 and -29.5551 respectively. Interestingly, even though CO_2 emissions have negative impact on income, the coefficients for the interactive term between CO_2 emissions and all the three institutional indicators, namely law and order, corruption and institutional composite index are positive and statistically significant at 1 percent.

From Equations (5) to (7), it can be found that the coefficient for the three interaction terms take the values of 23.9850, 10.0403 and 32.3412 respectively. The results provide evidence that the interaction between CO_2 emissions and institutional variables has a complementary effect which implies interdependence between the two

[39] Refer Jaccard and Turrisi (2003) for details regarding interaction effects.

variables. From the results, it can be concluded that CO_2 emissions have a negative impact on income except in the case where law and order, corruption level and the overall institutional quality have sufficiently improved. This view is supported by Carlsson and Lundstrom (2003), Eriksson and Persson (2003) and Tamazian and Rao (2009) who suggest that better quality of institutions plays a vital role in ensuring high economic growth while keeping the environment clean.

In addition, the instruments used are appropriate for the estimation as the statistic of Sargan test reported in Table 5.1 indicates that the null hypothesis (without over-identifying restrictions) has failed to be rejected.

The findings obtained by grouping all the countries together as above may not fully reflect the true picture of what is going in different countries based on their stage of development. Thus, in order to examine the degree to which the above estimated relationships differ with the stage of development, it is important to divide the 103 sample countries in accordance to the stage of development based on World Bank Income Classification, as suggested by Coondoo and Dinda (2002), Demetriades and Law (2006), Lee and Kim (2008), in the analysis of their growth model. To achieve the objective above, the empirical model of this study is then re-estimated by utilising four different panels of high income, upper middle income, lower middle income and low income countries. The results of the four income groups are discussed in subsections below.

5.3 CO_2 Emissions, Institutional Quality and Income in High Income Countries, 1989-2008

Table 5.2 displays the results of the relationship between CO_2 emissions, institutional quality and income for high income countries. Specifically, Equation (1) excludes institutional indicators. The institutional factors are included in Equation (2), (3) and (4) while the interactive term is demonstrated in equation (5), (6) and (7). Overall, most of the estimated coefficients of the explanatory variables turn out to be consistent with theory.

As shown in Table 5.2, the value of the coefficients for capital stock emerges as negative and significant at standard significance level in most of the regressions. This suggests that capital stock and income are negatively associated. As capital stock increases, the GDP per capita will tend to decline. This may in turn implies that high income countries are experiencing the stage of diminishing return to capital in their production processes.

In addition, the results reported in Table 5.2 provide strong evidence that there is a negative relationship between inflation and income. The coefficients are negative and statistically significant at 1 percent significance level in all specifications. This means that macroeconomic instability would cause deterioration in economic performance, as mentioned by economists such as Jung and Mashall (1986), and Risso and Carrera (2009).

Table 5.2: CO_2 Emissions, Institutional Quality and Income in High Income Countries, 1989-2008

Variable	Excluding Institutional Quality	LO		COR		CI	
	Equ. 1	Equ. 2	Equ. 5	Equ. 3	Equ. 6	Equ.4	Equ.7
GDP_{t-1}	0.3319*** (10.3850)	0.3297*** (17.6116)	0.6135*** (5.4973)	0.2661*** (11.9614)	0.2163** (2.3680)	-0.0037 (-0.1422)	0.2404*** (4.5967)
CS	-1.9788*** (-4.6389)	-1.9621** (-2.1864)	-1.4106** (-2.1087)	1.5119* (1.7175)	-2.6473** (-2.4096)	-6.9160*** (-17.8537)	-1.4470 (-0.8542)
CO2	3.1690*** (2.7730)	2.2814*** (4.3809)	48.9341*** (3.7161)	9.5014*** (5.2974)	18.4432*** (3.8777)	8.0486*** (11.3830)	24.9907** (2.0186)
X	0.9298** (2.1507)	0.2883 (0.6118)	2.4947*** (5.2520)	-1.2735*** (-2.7977)	2.5410** (2.2905)	6.9881*** (22.6504)	1.1079 (0.8017)
FDI	0.0177*** (3.5732)	0.0247* (1.6814)	0.0225*** (3.5714)	0.0050* (1.7319)	0.0231*** (5.4401)	0.0183*** (4.8489)	0.0246** (2.5619)
INF	-0.1419*** (-3.3627)	-0.1638*** (-2.7965)	-0.5213*** (-6.9808)	-0.2449*** (-3.1359)	-0.2630*** (-3.5330)	-0.8069*** (-15.1940)	-0.2843*** (-3.0283)
LO		0.8506*** (4.8654)	8.9162*** (2.7322)				
COR				-0.9095*** (-4.8740)	4.4957*** (3.2810)		
CI						0.9346** (2.1993)	7.4880** (2.4724)
LO x CO2			-36.7836***				

			(-2.8046)				
COR x CO2					-13.4149*** (-2.7453)		
CI x CO2							-22.4362* (-1.8767)
Diagnostic Checking							
Sargan test (p-value)	0.5657	0.6224	0.6661	0.5167	0.7294	0.6290	0.8545
Obs.	558	558	558	558	558	558	558

Notes:
Dependent variable is real GDP per capita.
All the variables are taken in differences and lagged one period.
The Sargan Chi-square statistic tests the null hypothesis of no correlation between the instruments and residuals.
The figures in the parentheses are t-statistics.
*, ** and *** The coefficient is significant at 10%, 5% and 1% levels, respectively.
GDP_{t-1} = Initial Real Gross Domestic Product Per Capita
CS= Capital Stock
CO2= CO_2 Emissions
X= Exports
FDI= Foreign Direct Investment
INF= Inflation
LO= Law and Order
COR= Corruption
CI= Composite Index of Institutional Quality
LOCO2= Interaction Term of Law and Order and CO_2 Emissions
CORCO2= Interaction Term of Corruption and CO_2 Emissions
CICO2= Interaction Term of Composite Index and CO_2 Emissions
Different lag of dependent variable (GDP) for instrumental variables are used in different models. The instrumental variables used are not listed due to different lag of GDP used. Lag structure is chosen based on Newey-West criteria.

Based on the results shown in Table 5.2, CO_2 emissions have a positive link with income in all the regressions. For example, in Equation (1) that excludes institutional quality, the coefficient carries the value of 3.1690. On the other hand, in Equations (2), (3) and (4) that include institutional quality, it is indicated that the values of coefficients are 2.2814, 9.5014 and 8.0486 respectively. All values are statistically significant at 1 percent level of significance, except Equation (7) where the significance level is 5 percent. The positive and significant relationship between CO_2 emissions and income suggests that CO_2 emissions do contribute to economic development in high income countries. This finding is consistent with the results obtained by past studies such as Coondoo and Dinda (2002) and Dinda (2009). They discovered that CO_2 emission is the cause of economic growth in developed countries. In other words, a rise in emission is required to increase income. This positive link is common among the developed countries particularly at the stage of their industrialization.

Table 5.2 also shows the results for the impact of exports on income. The variables are found to have a positive relationship, as indicated by the coefficients in almost all the equations. Besides coefficients in Equation (2) and Equation (7) which are insignificant, all other estimated coefficients are statistically significant at the usual level of significance. For instance, Equation (1) portrays that the coefficient is positive (0.9298) and significant at 5 percent significance level. This result is supported by many of the existing literature like Frankel and Romer (1999) and Konya (2006). A few reasons can explain why export activities is the key factor contributing to economic growth. First of all, export expansion stimulates the production of more goods for exports that makes the exploitation of economies of scale and country's comparative advantages possible. Besides, stiff foreign market competition encourages technological innovation in the domestic country. Furthermore, the foreign exchange earned from exports enables countries to raise imports of capital goods as well as technologies and in turn further increases production and income.

In the case of foreign direct investment, it has a positive effect on income as shown by all equations in Table 5.2. All the coefficients are reported to be positive and statistically significant at the standard level of significance. In Equations (1), (2), (3) and (4), for example, the coefficients are displayed as 0.0177, 0.0247, 0.0050 and 0.0183 respectively. The positive and significant relationship between the two variables has proven the importance of foreign direct investment in promoting growth in developed countries, as suggested by several other studies. For instance, studies by Barry and Bradley (1997) for Ireland, Liu, Siler, Wang, and Wei (2000) for the United Kingdom and Schneider (2005) for some developed countries have provided evidence of a positive relationship. Apparently, foreign direct investment is beneficial to high income countries in the sense that it has helped to encourage capital accumulation and knowledge spillovers in these countries.

When it comes to examining the impact of different institutional factors on income, it is discovered from Equations (2) to (4) that all the institutional indicators (law and order, degree of corruption and institutional composite index) have a positive influence on GDP per capita. In relation to this, both law and order and composite index are found to have positive coefficients of 0.8506 and 0.9346. The coefficients are statistically significant at 1 percent and 5 percent significance level respectively. Two main reasons can be put forth to explain the above results. First, an overall improvement in the quality of institutions can provide a favourable environment for the adoption of cooperative solutions that will in turn lead to better economic growth. Besides, developed countries, for example, with good law and order are less prone to conflict and crisis that may hinder the progress of economic development. According to Collier (2000) and Easterly (2001), the existence of law and order can help to reduce the possibility of social or ethnic conflicts.

Surprisingly, however, the coefficient for corruption shown in Equation (3) is negative at the value of -0.9095 and significant at the significance level of 1 percent, indicating that corruption does lead to better growth in high income countries. The result is in line with some of the existing literature such as Kaufmann (1997), Knack and Keefer (1995), and Rock and Bonnett (2004) who believe that bribery can sometimes be efficiency-enhancing. For instance, Rock and Bonnett (2004) discover that corruption tends to stimulate investment and growth in East Asian Countries which include South Korea and Japan. The positive relationship between corruption and income may be explained by the fact that bribes encourage FDI by making it easier for foreign firms to get entry permission and access to public funded projects, and in turn leads to higher economic growth (Egger & Winner, 2005).

From the value of coefficients, it is also found that corruption plays a more vital role in explaining growth than law and order in high income countries. This contradicts with some of the existing literature like Tanzi and Davoodi (2002) and Aixala and Fabro (2008) who highlight the importance of corruption only in less-developed countries. Among the three institutional indicators, it is shown that the overall institutional quality has a greater impact on income than law and order or corruption alone in the developed world. The above results obtained support the hypothesis that overall maintenance of institutional quality and existence of law and order help to enhance growth. The findings are in line with many of the existing literature such as Aron (2000), Butkiewicz and Yanikkaya (2006) and Siddiqui and Ahmed (2013) who argue that economic performance of a country depends very much on its institutional quality.

To investigate how much the institutional quality influences the impact of CO_2 emissions on income, Equations (5), (6) and (7) include the interaction term (constructed as a product of institutional factor and CO_2 emissions) between various types of institutional indicators and CO_2 emissions. As presented in Table 5.2, the coefficients for CO_2 emissions are still positive and statistically significant. The coefficient for CO_2 emissions, for instance, that appears in Equation (5) is 48.9341 and significant at 1 percent significance level. However, the interaction term between law and order and CO_2 emissions is negative (-36.7836) and statistically significant at 1 percent. Most importantly, the result implies that with law and order, it can help to reduce the impact of CO_2 emissions on income in high income countries. This finding, which is consistent with Panayotou (1997) and Tamazian and Rao (2009), confirms the hypothesis that the existence of law and order enables countries to reduce the environmental costs of better economic performance.

A similar result is shown for the interaction term between corruption and CO_2 emissions as indicated by Equation (6). The coefficient of the interaction term between the two variables is also negative (-13.4149) and significant at the same level with the estimated coefficient for CO_2 emissions as 18.4432 which is positive and significant at 1 percent. Based on this result, it can be suggested that CO_2 emissions have a positive relationship with income in high income countries, except in the situation where the corruption level is low. This finding is in line with Leitao (2010) and Lopez and Mitra (2000) who claim that the degree of corruption does play a role in explaining the impact of CO_2 on income. According to them, countries with lower degree of corruption would tend have better environmental quality despite improved economic performance as compared to those more corrupted nations.

As expected, the interaction term between the composite index of institutional quality and CO_2 emissions turns out to be negative (-22.4362) and significant at 10 percent while the coefficient of CO_2 emissions remains as positive (24.9907) and significant (at 5 percent significance level) as shown in Equation (7). This result indicates that a certain level of institutional quality is a vital factor for a country to experience continuous economic growth without harming its environment. The above result is consistent with the findings provided by Carlsson and Lundstrom (2003), Deacon (1999), and Eriksson and Persson (2003) who suggest that a better institutional quality helps to reduce the adverse effect of CO_2 emissions on economic growth.

The statistic of Sargan test shown in Table 5.2 indicates that the null hypothesis (no over-identifying restrictions) has failed to be rejected. Hence, it can be concluded that the instruments used are appropriate for the estimation.

5.4 CO_2 Emissions, Institutional Quality and Income in Upper Middle Income Countries, 1989-2008

Table 5.3 reports the results for upper middle income countries. Equation (1) to (4) exclude the interaction terms between CO_2 emissions and institutional indicators whereas the remaining equations do consider these terms.

As noticed from the table, capital stock is negatively related to income, with the estimated coefficient revealed as negative and statistically significant at conventional level of significance in all regressions, except equation (6) which is insignificant. For instance, the coefficients found in Equation (1) to (4) that exclude interactive terms are all negative and significant at 1 percent. This indicates that, for upper middle income countries, the law of diminishing returns to capital is taking place as suggested by Choong, Baharumshah, Yusop, & Habibullah (2010). The finding is similar to what is found in high income countries.

As for inflation, the estimated coefficients are negative and 1 percent significant in Equations (3), (5) and (6). In other equations, the coefficient is found to be either positive or insignificant or both. The results suggest that inflation has a negative impact on income which is the same as the findings obtained in high income

Table 5.3: CO2 Emissions, Institutional Quality and Income in Upper Middle Income Countries, 1989-2008

Variable	**Excluding Institutional Quality**	**LO**		**COR**		**CI**	
	Equ. 1	**Equ. 2**	**Equ. 5**	**Equ. 3**	**Equ. 6**	**Equ.4**	**Equ.7**
GDP_{t-1}	0.1020*** (2.9642)	-0.0500 (-1.3570)	-0.0766 (-1.1499)	0.1331 (1.3467)	0.1178 (1.0671)	0.0060 (0.1131)	-0.0061 (-0.1011)
CS	-6.9727*** (-7.0514)	-7.9341*** (-5.3779)	-11.6785** (-2.5384)	-3.2557*** (-2.9482)	-1.5638 (-0.8424)	-11.4709*** (-5.9456)	-9.6686*** (-3.0968)
CO2	-3.5003* (-1.6173)	1.7306 (0.9198)	-7.9579* (-1.4490)	-7.6100* (-1.6158)	-11.7499* (-1.9218)	-3.7406 (-1.4559)	-35.1989* (-1.8715)
X	5.3614*** (3.0745)	5.1874*** (2.7186)	5.2181** (2.5832)	3.2213*** (3.0196)	2.2588 (1.5749)	8.5518*** (5.9444)	6.5874*** (2.7374)
FDI	0.2847* (1.8578)	0.2502** (2.3345)	0.2091*** (3.0698)	0.1826*** (3.4337)	0.1573* (1.6840)	0.2071*** (4.5056)	0.1957*** (2.8053)
INF	0.0052* (1.7388)	0.0061*** (3.0546)	-0.0394** (-2.0420)	-0.2327*** (-6.4881)	-0.2487*** (-5.2376)	0.0124 (1.2895)	0.0153 (1.0285)
LO		1.5180*** (3.4708)	-3.7481*** (-2.6632)				
COR				1.1527* (1.6024)	-2.8079 (-0.6622)		
CI						1.9647** (2.0750)	-9.0372 (-1.2810)
LO x CO2			10.5516***				

			(2.6727)				
COR x CO2					7.0558 (1.0396)		
CI x CO2							34.9963* (1.6765)
Diagnostic Checking							
Sargan test (p-value)	0.7032	0.8990	0.8262	0.8779	0.8854	0.7277	0.7444
Obs.	486	486	486	486	486	486	486

Notes:
Dependent variable is real GDP per capita.
All the variables are taken in differences and lagged one period.
The Sargan Chi-square statistic tests the null hypothesis of no correlation between the instruments and residuals.
The figures in the parentheses are t-statistics.
*, ** and *** The coefficient is significant at 10%, 5% and 1% levels, respectively.
GDP_{t-1} = Initial Real Gross Domestic Product Per Capita
CS= Capital Stock
CO2= CO_2 Emissions
X= Exports
FDI= Foreign Direct Investment
INF= Inflation
LO= Law and Order
COR= Corruption
CI= Composite Index of Institutional Quality
LOCO2= Interaction Term of Law and Order and CO_2 Emissions
CORCO2= Interaction Term of Corruption and CO_2 Emissions
CICO2= Interaction Term of Composite Index and CO_2 Emissions
Different lag of dependent variable (GDP) for instrumental variables are used in different models. The instrumental variables used are not listed due to different lag of GDP used. Lag structure is chosen based on Newey-West criteria.

countries. This in turn implies that unstable macroeconomic condition lowers economic growth in upper middle income countries.

The sign of coefficient for CO_2 emissions is different from that of the developed countries. In the case of upper middle income countries, the coefficients of CO_2 emissions are reported as negative instead of positive as what happens in high income countries. However, the coefficients are only statistically significant at 10 percent level, except for Equation (2) and (4) which are insignificant. In Equations (1) and (3), for example, the estimated coefficients are reported as -3.5003 and -7.6100 respectively. The coefficients from Equations (5) to (7) which include the interaction terms are demonstrated as -7.9579, -11.7499 and -35.1989. The above findings indicate that CO_2 emissions and income are negatively correlated in upper middle income countries. This also means that as environment is getting dirtier in a country, economic performance of the country would be affected. This result is consistent with the notion that environmental degradation leads to a decline in income as productivity of man-made capital and labour deteriorates due to pollution as mentioned by Borhan et al. (2011) and Lean and Smyth (2010).

As the results from Table 5.3 show, the coefficients for exports are positive and statistically significant at the standard level of significance, in most of the regressions. The results are similar to that of high income countries. Such results are also in line with the findings obtained by the previous studies like Balassa (1978), Edwards (1998), and Hsiao and Hsiao (2006) who argue that export expansion is a main contributor for economic growth due to the positive externalities it produces.

For instance, those firms who engage in export activities may be able to enjoy certain benefits such as efficient resource allocation, economies of scale, greater capacity utilisation and technological improvement as a result of stiff foreign competition that will in turn help in stimulating economic growth.

There is strong evidence based on the results in Table 5.3 that the impact of foreign direct investment on income in upper middle income countries follows an outcome similar to the developed world. The results indicate that foreign direct investment, as expected, contributes to income positively. Significant coefficients are found for foreign direct investment as shown in Table 5.3. In fact, the estimated coefficients in all regressions are discovered as positive and significant at different levels of significance. For instance, in Equation (1) where the institutional variables are excluded, the coefficient is shown as 0.2847 and it is 10 percent statistically significant. Foreign direct investment is beneficial to economic growth because it encourages the use of latest technologies and managerial expertise that helps to enhance productivity growth as proposed by many (Basu, Chakraborty, & Reagle, 2003; Borensztein, De Gregorio, & Lee, 1998; Lee, 2013; Salisu & Sapsford, 1996; Whalley & Xin 2010).

From Equations (2) to (4) of Table 5.3, it can be seen that the estimated coefficients for the three institutional variables are all positive and significant at the conventional levels of significance. The coefficients for law and order, corruption and the composite index of institutional quality are demonstrated as 1.5180, 1.1527 and 1.9647 respectively. From the results, all phenomena occur as expected. First, the coefficients for law and order as well as the composite index turn out to be positive. Second, it is found that the impact of the overall quality of institutions on income is the greatest among the three institutional indicators. Third, the positive coefficient for corruption is within expectation indicating that low corruption leads to economic growth. However, it is in sharp contrast to the results obtained in developed countries and even in lower middle and low income countries. In other income groups, the corruption coefficient is found to be negative.

This result is supported by many past studies such as Aixala and Fabro (2008), Beekman, Bulte and Nillesen (2013), De Jong and Bogmans (2011), Olken (2006), Olken and Pande (2012), and Tanzi and Davoodi (2002), who argue that corruption is detrimental to economic growth because it discourages FDI inflow, harms international trade and leads to adverse distributional consequences. In the upper middle income countries, corruption dampens economic growth by hindering the growth of small and medium enterprises. It is because corruption diverts resources into unproductive activities that include rent seeking.

The above findings indicate that both law and order and the overall institutional quality play an important role in stimulating better economic performance in upper middle income countries which is in line with some studies. For instance, as suggested by Gagliardi (2008), all economic actors are affected by institutions. Good institutions can help to smooth coordination of agents' plans, encourage cooperative behaviour, reduce opportunism, enable agents to internalise externalities, and in turn causes higher economic growth. Other researchers who have emphasised the significance of good institutions in promoting growth include Hasan, Wachtel and Zhou (2009), Mauro (1995), and Subramaniam (2007). In the mean time, the positive coefficient for corruption suggests that the variable seems to have an adverse effect on income in upper middle income countries.

Estimates with the inclusion of interactive terms between CO_2 emissions and various institutional variables are reported from Equations (5) to (7) in Table 5.3. The coefficients for all the interaction terms are found to be positive while the coefficients for CO_2 emissions remain as negative. In this case, the estimated coefficients for CO_2 emissions carry the values of -7.9579, -11.7499, and -35.1989 respectively and significant at 10 percent as shown in Equations (5) to (7). However, the values of coefficient for the interactive terms of law and order-CO_2, corruption-CO_2, and composite index-CO_2 are presented as 10.5516, 7.0558 and 34.9963. The coefficient for the corruption-CO_2 interactive term is insignificant while the others are significant at standard significance levels. The above results are in reverse to those found in high income countries. The positive interactive terms indicate that a complementary effect exists between CO_2 emissions and institutional quality in the upper middle income countries. That means a favourable effect of CO_2 emissions on income can only be achieved with the presence of proper institutional quality. Such findings are supported by some existing literature which highlights the role of institutional quality in contributing to green environment along with excellent economic growth (Panayotou, 1997; Tamazian & Rao, 2009; Torras & Boyce, 1998).

Since the null hypothesis (no over-identifying restrictions) has failed to be rejected as shown by the statistic of Sargan test reported in Table 5.3, the instruments used are appropriate for the estimation.

5.5 CO_2 Emissions, Institutional Quality and Income in Lower Middle Income Countries, 1989-2008

Results for the estimated specifications for lower middle income countries are presented in Table 5.4. Similar to the results found in high income and upper middle income countries, capital stock has a negative impact on income as well in lower middle income countries. The coefficients demonstrated in Equations (1) and (4) are negative and 1 percent significant while other equations show insignificant results. The result implies that income declines as capital stock increases. This may be due to the fact the foreign capital inflows crowd out domestic investment in these lower income countries with low absorptive capacity such as undeveloped financial market and poor educational system. According to Adams (2009) and Morrissey and Udomkerdmongkol (2011), crowding out of domestic investment by foreign direct investment that results in a reduction for a country's benefits is a common phenomenon particularly in less developed countries.

As shown in Table 5.4, the coefficient for inflation appears to be negative and statistically significant in most of the regressions. This suggests that inflation and income are negatively associated as what happens in upper middle income and high

Table 5.4: CO_2 Emissions, Institutional Quality and Income in Lower Middle Income Countries, 1989-2008

Variable	Excluding Institutional Quality	LO		COR		CI	
	Equ. 1	Equ. 2	Equ. 5	Equ. 3	Equ. 6	Equ.4	Equ.7
GDP_{t-1}	0.1525*** (5.3290)	0.1528*** (4.4432)	0.2754*** (9.1215)	0.3244*** (23.7677)	-0.3438*** (-4.2933)	-0.0733** (-2.4219)	0.3777*** (13.7170)
CS	-3.1064*** (-3.1340)	1.2383 (1.0563)	0.7057 (0.3611)	-0.1033 (-0.0953)	1.0115 (0.8101)	-2.5726*** (-6.7605)	-1.4421 (-0.6419)
CO2	-2.4637* (-1.7738)	-6.3618*** (-6.8637)	-20.9345*** (-2.9390)	-10.1389*** (-13.5947)	-15.1362** (-2.4111)	-2.2707** (-2.4603)	-36.8256 (-1.5749)
X	4.6895*** (5.6788)	2.7240*** (5.0255)	3.1475*** (5.3985)	3.3338*** (7.6342)	-0.1928 (-0.0842)	3.4690*** (6.1453)	3.5498*** (4.2511)
FDI	-0.2206*** (-4.3681)	-0.2877*** (-9.9617)	-0.2257*** (-8.8808)	-0.0864* (-1.6534)	-0.5950*** (-6.5523)	-0.2546*** (-7.8041)	-0.1320* (-1.8830)
INF	-0.0045** (-2.5765)	0.0022*** (6.0576)	-0.0022*** (-4.7172)	-0.0010*** (-7.5843)	0.0416 (0.7796)	-0.0940*** (-11.7788)	-0.0008*** (-2.9498)
LO		0.1441 (0.8248)	-4.8275* (-1.8976)				
COR				-1.1342** (-2.4953)	-5.6278** (-2.0943)		
CI						0.0466 (0.1211)	-11.4471 (-1.4954)
LO x CO2			13.4748*				

			(1.7303)				
COR x CO2					11.0150* (1.8601)		
CI x CO2							29.9482 (1.2706)
Diagnostic Checking							
Sargan test (p-value)	0.7235	0.7768	0.7614	0.8098	0.7533	0.8048	0.8811
Obs.	522	522	522	522	522	522	522

Notes:
Dependent variable is real GDP per capita.
All the variables are taken in differences and lagged one period.
The Sargan Chi-square statistic tests the null hypothesis of no correlation between the instruments and residuals.
The figures in the parentheses are t-statistics.
*, ** and *** The coefficient is significant at 10%, 5% and 1% levels, respectively.
GDP_{t-1} = Initial Real Gross Domestic Product Per Capita
CS= Capital Stock
CO2= CO_2 Emissions
X= Exports
FDI= Foreign Direct Investment
INF= Inflation
LO= Law and Order
COR= Corruption
CI= Composite Index of Institutional Quality
LOCO2= Interaction Term of Law and Order and CO_2 Emissions
CORCO2= Interaction Term of Corruption and CO_2 Emissions
CICO2= Interaction Term of Composite Index and CO_2 Emissions
Different lag of dependent variable (GDP) for instrumental variables are used in different models. The instrumental variables used are not listed due to different lag of GDP used. Lag structure is chosen based on Newey-West criteria.

income countries. The implication of the result is that macroeconomic instability can cause deterioration in economic performance for lower middle income countries.

Based on results shown in Table 5.4, it is found that the estimated coefficient for CO_2 emissions is negative in all specifications, irrespective of whether interactive terms are included. Most importantly, most of the coefficients are significant at usual levels of significance. The results are the same as those of upper middle and low income nations, showing that CO_2 emissions have a negative impact on income in developing countries, but not in developed countries. The findings are consistent with some empirical studies such as Borhan et al. (2011) and Stern et al. (1996) who claim that as pollution worsens, income would deteriorate as well due to the fact that environmental degradation reduces the productivity of man-made capital and labour.

Similar to upper middle income and high income countries, the impact of exports on income is reported as positive. In Table 5.4, it is indicated that the coefficients for exports in most of the regressions (regardless the inclusion of interaction terms) are shown as positive and 1 percent significant. This result is not surprising as many researchers have agreed that exports lead to growth due to the fact that exports enable transfers of resources to more productive export industries, earn foreign exchange to make imports of capital goods possible, help to expand efficient market size, and bring in economies of scale (Frankel & Romer, 1999; Hsiao & Hsiao, 2006; Tekin, 2012).

However, for foreign direct investment, the results obtained are opposite of those found in upper middle income and high income countries. As reported in the table, the coefficients for foreign direct investment are negative and statistically significant at standard levels of significance in all specifications. For example, the value of coefficient in Equation (1) that excludes the institutional quality is found to be -0.2206. This finding indicates that foreign direct investment and income are negatively associated, which also means foreign direct investment does not help in promoting economic growth in lower middle income countries. In fact, it is harmful to the economy. The adverse effect of foreign direct investment on income can be explained by the fact that lower income countries are still lacking of some important factors such as sufficient human capital that can realize the positive relationship between the two variables. According to Aizenman and Noy (2006) and Herzer et al. (2007), the positive effect of foreign direct investment on income depends very much on factors such as degree of trade openness, the depth of financial market, and the seriousness of crowding out effect in the host countries. With the absence of some favourable conditions for foreign direct investment, it is not surprising that a negative link exists between foreign direct investment and income in the lower middle income countries.

When it comes to institutional variables, both the coefficients for law and order and the composite index of institutions show a positive value (0.1441 and 0.0466 respectively), but insignificant. The insignificant results may suggest that even though law and order and other institutions do exist in lower middle income countries, it appears that these institutions fail to promote economic growth due to lack of compliance and enforcement. As mentioned by Zhang (2008), the problem of weak compliance and poor enforcement is very common in the developing countries.

However, corruption has a negative and significant coefficient of -1.1342, indicating that economic performance will tend to improve with higher degree of corruption. Occasionally, according to some researchers such as Bardhan (1997) and Knack and Keefer (1995), who believe in the "grease the wheels" hypothesis, bribes can help to improve efficiency and enhance economic performance by acting as a trouble saving device particularly in developing countries with pervasive and cumbersome regulations.[40] In addition, the value of coefficient for corruption is the highest among all the three institutional variables, showing that the degree of corruption plays the most important role in affecting income as compared to the other indicators. This finding is in fact in line with some previous studies which suggest that corruption is the most significant institutional variable affecting growth in poor countries (Aixala & Fabro, 2008; Tanzi & Davoodi, 2002).

Equations (5) to (7) of Table 5.4 which include the interactive terms between CO_2 emissions and institutional indicators suggest that the coefficient for CO_2 emissions on its own is still negative at the value of -20.9345, -15,1362 and -36.8256 respectively. The interaction terms, however, are positive and statistically significant only at 10 percent level of significance in Equations (5) and (6) with the value of 13.4748 and 11.0150. In contrast, the coefficient in Equation (7) is though positive, but not significant. These findings seem to indicate that without good institutions, the

[40] See also Aidit (2003) for the details of efficient corruption and side payments.

relationship between CO_2 emissions and income remains unfavourable. However, when institutional quality improves, countries will tend to have better economic performance accompanied by good environmental quality. The results are consistent with Carlsson and Lundstrom (2003) and Leitao (2010) who also find a vital role of institutions in explaining the relationship between CO_2 emissions and income.

The statistic of Sargan test presented in Table 5.5 indicates that the null hypothesis of no over-identifying restrictions has not been rejected. As a conclusion, the instruments used are appropriate for the estimation.

5.6 CO_2 Emissions, Institutional Quality and Income in Low Income Countries, 1989-2008

The results for low income countries are demonstrated in Table 5.5. In contrast to the results found in lower middle income, upper middle income and high income countries, capital stock has a positive effect on income in low income countries. As observed in Table 5.5, capital stock coefficients in all equations are positive and statistically significant at standard level of significance, except for coefficient in Equation (5) which is insignificant. The findings suggest that low income countries are still operating at the initial stage of production whereby income rises as capital stock increases.

For inflation, it is found that the coefficients are positive and significant at 1 percent significance level in Equations (1), (2) and (4) with the values of 0.0004,

Table 5.5: CO2 Emissions, Institutional Quality and Income in Low Income Countries, 1989-2008

Variable	**Excluding Institutional Quality**	**LO**		**COR**		**CI**	
	Equ. 1	**Equ. 2**	**Equ. 5**	**Equ. 3**	**Equ. 6**	**Equ.4**	**Equ.7**
GDP_{t-1}	-0.1648*** (-5.9884)	-0.1556*** (-3.8279)	0.2973*** (7.3199)	0.0062 (0.2946)	0.2255*** (3.4603)	-0.1720*** (-5.4119)	0.2015** (2.2249)
CS	7.4055*** (11.0650)	7.7924*** (5.3486)	3.4662 (0.8205)	8.5934*** (6.4262)	3.6382 (0.3317)	6.3941*** (4.4449)	10.2035* (1.6922)
CO2	-6.8275*** (-4.1916)	-8.7189** (-2.1799)	-28.1126* (-1.6481)	-11.6770** (-2.0712)	-4.0721 (-0.7060)	-6.4203*** (-3.5433)	-24.7874** (-2.0549)
X	-7.3650*** (-4.9592)	-8.2719*** (-2.8076)	-4.5471 (-1.5767)	-12.8764*** (-15.6377)	-4.6241 (-1.0375)	-7.4133*** (-4.1673)	-5.4801 (-0.4896)
FDI	-0.2305*** (-21.8005)	-0.2265*** (-15.2746)	-0.2679*** (-7.3618)	0.0316*** (2.8206)	0.0759*** (2.8844)	-0.2284*** (-22.1915)	0.1072** (1.9993)
INF	0.0004* (1.9288)	0.0004* (1.7490)	-0.0228 (-1.2944)	-0.0174 (-0.3345)	0.0321 (0.3177)	0.0003* (1.8327)	0.1427 (0.6892)
LO		-1.0994 (-0.6393)	-21.8437* (-1.9631)				
COR				-3.8986*** (-12.3413)	-2.4396** (-2.3808)		
CI						2.5924 (1.3369)	-12.6550* (-1.7081)
LO x CO2			35.8295**				

			(2.1604)				
COR x CO2					4.6456*** (4.1447)		
CI x CO2							27.3760*** (5.7674)
Diagnostic Checking							
Sargan test (p-value)	0.8192	0.8331	0.9828	0.8600	0.9527	0.8552	0.9571
Obs.	288	288	288	288	288	288	288

Notes:
Dependent variable is real GDP per capita.
All the variables are taken in differences and lagged one period.
The Sargan Chi-square statistic tests the null hypothesis of no correlation between the instruments and residuals.
The figures in the parentheses are t-statistics.
*, ** and *** The coefficient is significant at 10%, 5% and 1% levels, respectively.
GDP_{t-1} = Initial Real Gross Domestic Product Per Capita
CS= Capital Stock
CO2= CO_2 Emissions
X= Exports
FDI= Foreign Direct Investment
INF= Inflation
LO= Law and Order
COR= Corruption
CI= Composite Index of Institutional Quality
LOCO2= Interaction Term of Law and Order and CO_2 Emissions
CORCO2= Interaction Term of Corruption and CO_2 Emissions
CICO2= Interaction Term of Composite Index and CO_2 Emissions
Different lag of dependent variable (GDP) for instrumental variables are used in different models. The instrumental variables used are not listed due to different lag of GDP used. Lag structure is chosen based on Newey-West criteria.

0.0004 and 0.0003 respectively. The results are different from high income countries in which the sign of the coefficients is reported as negative. However, the coefficient is insignificant in all other equations. The positive and significant link between inflation and income is supported by macroeconomic theory proposed by the structuralists who suggest the view that inflation is an important factor leading to growth as depicted by the Phillips Curve.

Table 5.5 also reveals that most of the coefficients on CO_2 emissions are negative regardless of whether institutional factors are included or excluded. For example, the coefficient in Equations (1), (2), (3) and (4) take the values of -6.8275, -8.7189, -11.6770 and -6.4203 respectively and all are significant at either 1 percent or 5 percent level of significance. Even when the interaction terms between institutional variables and CO_2 emissions are included, the coefficients are still negative and statistically significant, as shown in Equations (5) and (7). The results are similar to those found in the lower middle and upper middle income nations but different from the positive relationship between CO_2 emissions and growth reported in high income countries. This finding implies that an increase in CO_2 emissions may lead to a decline in income, which is in line with the empirical work by Borhan et al. (2011), Lean and Smyth (2010) and Stern et al. (1996). According to these researchers, environmental degradation decreases income as productivity of man-made capital and labour decline due to pollution. When pollution worsens, there will be losses in labour days as human health deteriorates. Besides, the quality of industrial equipment tends to decline with more severe pollution problem.

Interestingly, it is shown in Table 5.5 that the impact of exports on income is negative and significant in most regressions with or without the presence of institutional variables in low income countries. For instance, in Equation (1) with the exclusion of institutional quality, the coefficient for export is -7.3650 at the significance level of 1 percent. The exceptions occur in Equations (5), (6) and (7) where the coefficients remain negative but insignificant. The above findings are not similar to the results obtained in other income groups, namely lower middle, upper middle and high income countries. In these richer countries, on the contrary, there is a positive relationship between exports and income. However, the fact that exports have a negative effect on income which contradicts with the export-led-growth hypothesis is not surprising in low income countries. According to some existing literature such as Adelman (1984), Bahmani–Oskooee and Economidou (2009), Jaffe (1985), Reppas and Christopoulos (2005), there are a few reasons that can explain why exports are not able to lead to growth in low income countries. The reasons given include worsening of terms of trade and inefficient demand for the products of less developed countries, unequal exchange, limited size of market in developed countries that can absorb exports from low income countries as well as unstable and unpredictable global market.

Similar to exports, foreign direct investment (FDI) has a negative impact too on income in low income countries. Most of the coefficients for FDI shown in Table 5.5 are negative and statistically significant. For instance, the coefficients in Equations (1), (2), (4) and (5) are negative and statistically significant at 1 percent significance level. The coefficients found are -0.2305, -0.2265, -0.2284 and -0.2679 respectively. The results reported are similar to the findings obtained in lower middle income countries that also suggest a negative FDI-growth nexus. In fact, it is not surprising for less developed countries to demonstrate such a result. This finding is supported by some of the existing literature like Aitken and Harrison (1999), Herzer et al. (2007), and Xu (2000), which suggest that the positive link between FDI and income may not realise due to many reasons in developing countries. One of the most important reasons is that local firms in less developed countries are unable to compete with the lower-cost foreign firms, which may lead to a reduction in local productivity. Another significant reason may be there is insufficient human capital in poorer countries that is able to absorb the advanced technologies transferred through FDI. Generally, the degree to which FDI affects income is conditional on the economic and political factors such as degree of trade openness, human capital base, the development of financial market and technological development of the host countries (Akinlo, 2004; Mah, 2010; Xu, 2000). Interestingly, it can be noticed from Equations (6) and (7) of Table 5.5 that with good institutional quality, the negative relationship between foreign direct investment and income has become positive indicated by the positive coefficients obtained.

It is noticed from Table 5.5, Equation (2) that the estimated coefficient for law and order is negative (-1.0994) and insignificant statistically, indicating that law and order does not contribute to higher income in low income countries. Even though there are law and order in place aiming to bring about improved economic performance, it seems that they only look good on paper. In low income countries, the common problems faced are poor compliance and weak enforcement of law and order that result in poor regulatory outcomes, which will in turn affect income as suggested by Jalilian et al. (2006) and Zhang (2008). The same goes to the coefficient for composite index of institutional quality shown in Equation (4) which is found to be insignificant, though positive at the value of 2.5924. This result also indicates that due to improper governance, institutions fail to promote higher income in low income countries. The results obtained are similar to what found in lower middle income countries.

On the other hand, however, as shown in Equation (3), the estimated coefficient for corruption is relatively higher at the value of -3.8986 and statistically significant at 1 percent as compared to other institutional variables which are insignificant. The result implies that degree of corruption is one of the most important institutional indicators affecting growth and it is linked to income positively in low income countries. As highlighted in the study by Aixala and Fabro (2008) and Tanzi and Davoodi (2002), corruption is the most significant institutional factor influencing growth in poor countries. In these countries, corruption tends to stimulate economic growth because bribery is able to improve efficiency particularly in countries with the presence of poor legal system and burdensome regulations as suggested by some researchers such as Bardhan (1997) and Knack and Keefer (1995).

Referring to Equations (1) to (4), which exclude the interaction terms, it is discovered that the coefficients for CO_2 emissions are all significant and negative. With the inclusion of interactive terms, the value of the CO_2 coefficients remains negative and significant in Equations (5) and (7), except for equation (6) which is insignificant. However, the estimated coefficients of all three interactive terms are positively correlated with income, regardless of the institutional indicator applied. The coefficient of interaction term between law and order and CO_2 emissions is positive and significant at 5 percent. On the other hand, both the coefficients of interactive terms for corruption-CO_2 emissions and composite index-CO_2 emissions are 1 percent statistically significant. The results suggest that there is a complementary effect of CO_2 emissions and institutional quality on income as agreed by some previous researchers such as Leitao (2010) and Torras and Boyce (1998). This implies that a favourable impact of CO_2 emissions on income should be complemented by good institutional quality. With proper institutional quality, low income countries can achieve improvement in economic performance while preserving their environment as what happens in lower middle income and upper middle income countries.

Similar to other income groups, the results of Sargan test shown in Table 5.5 confirm that the null hypothesis has failed to be rejected. Thus, it can be said that the instruments used are appropriate for the estimation.

5.7 Conclusions and Discussions

Basically, this chapter attempts to investigate the role of institutional quality in explaining the relationship between CO_2 emissions and income in different income groups, namely high income, upper middle income, lower middle income and low income countries for the period 1989 to 2008. Besides, the extent to which some factors such as CO_2 emissions, institutional quality, exports and foreign direct investment in influencing income based on different income groups are also examined. In a nutshell, several principal results have emerged from this chapter.

First of all, it can be concluded that the impact of CO_2 emissions on income varies according to stages of development. In high income countries, CO_2 emissions have a positive effect on income, indicating that pollution due to industrialisation process has led to higher income growth in the developed world. However, CO_2 emissions and income are negatively linked in upper middle income, lower middle income and low income countries. The result implies that income can be adversely affected by CO_2 emissions due to reduction in productivity of man-made capital and labours in developing countries. Different results obtained in different income groups suggest that different policies are required in developed and developing countries to ensure sustainable growth without harming the environment.

As expected, law and order which is one of the institutional variables adopted has a positive and significant impact on income in all income groups, except low income and lower middle income countries. The results found in the poorer groups of countries are not significant, showing that there is lack of enforcement and compliance for law and order in these countries as suggested by Jalilian et al. (2006). In short, it can be said that law and order plays a significant role in encouraging growth only in high income and upper middle income countries.

On the other hand, it is found that degree of corruption and income are positively related in all income groups except upper middle income countries. Instead of "sanding the wheels" as what happens in upper middle income countries, the results indicate that corruption has helped to “grease the wheels” in other income groups. Interestingly, it is also discovered that corruption plays a more important role in explaining growth as compared to law and order in all income groups based on the value of coefficients estimated. This finding is not in line with the results of some researchers such as Aixala and Fabro (2008) and Butkiewicz and Yanikkaya (2006) who claim that corruption is the most significant institutional indicators affecting growth only in poor countries. In short, the results indicate that corruption is a more important institutional variable in explaining growth than law and order even in high income countries. When it comes to the composite index of institutional quality, it has a positive impact on income in both the developed and less developed countries. However, the coefficients are found to be insignificant in low income and lower middle income countries.

From the empirical results, it can also be noticed that CO_2 emissions contribute to a favourable impact on income with the presence of proper institutional quality in all income groups. This is clearly evident by the results obtained with the inclusion of interaction terms between CO_2 emissions and various institutional variables. In high income countries, for example, the initial positive coefficients of CO_2 emissions have become negative when interaction terms are included, suggesting that the dual goals of high income and good environmental quality can be achieved with the availability of proper institutional quality. In contrast, by considering the interaction terms in the developing countries, it is found that the coefficient for CO_2 emissions has changed from negative to positive showing that complementary effects do exist between CO_2 emissions and institutional variables on income. This finding further suggests the importance of institutional quality in contributing to an economy with robust growth, by yet clean environment, in the developing world. In short, institutional quality has played a vital role in explaining the effect of CO_2 emissions on income in all income groups as proposed by Leitao (2010) and Torras and Boyce (1998).

Looking at the relationship between exports and income, the results show that exports have a positive effect on income in all income groups, except low income countries. For low income countries, exports lead to a decline in income, instead. This result is not surprising due to the fact that poor countries may have to face problems such as unequal terms of trade and unstable global market.

From the results, it is also revealed that only high income and upper middle income countries are benefited from foreign direct investment. In lower middle and low income countries, however, FDI causes deterioration in income. The fact that FDI contributes to economic growth in richer countries is in line with previous studies who suggest that FDI tends to facilitate the transfers of technologies and management know-how; that in turn leads to economic growth in the host countries. However, low income and lower middle income countries are not able to capture the benefits of FDI due to their absorptive incapabilities such as poor human capital development, financial system, trade policy and institutional quality.

From the above discussion, it can be concluded that CO_2 emissions, institutional variables, exports and foreign direct investment are found to have varying impacts on income in different income groups with different stages of development.

Thus, it is essential for policy makers of different income groups to be aware of the differences and design appropriate policies to ensure continuous growth accompanied by superb environmental quality.

CHAPTER 6

SUMMARY, CONCLUSION AND POLICY IMPLICATIONS

6.1 Introduction

This chapter is made up of four sections. The first section presents a summary on the main conclusions of the statistical results and the economic interpretation of them, as discussed in the previous two chapters. Besides, an overall summary of the dissertation is also reported in this section. The most significant policy implications built on the statistical and economic analysis of the models used are presented in the second section. The third section highlights some limitations of this study. The last section identifies some potential areas for future researches on the EKC hypothesis as well as the relationship among CO_2 emissions, institutional quality and GDP in different income groups of countries.

6.2 Summary and Conclusions

According to the World Bank (2007), the emission of CO_2 is the main cause that has led to the problem of global warming and has captured the attention of many in the last decades. Lately, developed countries such as U.S. and U.K. have experienced a reduction in CO_2 emissions with sustained economic growth by exporting polluted industries to the less developed countries. On the other hand, the CO_2 emissions have been accelerating in the developing countries like China due to the expansion of industrialisation process and rapid economic growth. Thus, the developing nations are facing a dilemma of how to enjoy continuous growth while reducing emissions at the same time.

Today, countries are particularly interested in the relationship between environmental degradation and economic development which is of great importance to policy making. In the mean time, many countries have started to show interest in the role of institutional quality in promoting high economic growth while keeping the environment clean. In relation to this, numerous researches have been done attempting to figure out the relationship between CO_2 emissions and income. Other studies have been focused on the importance of institutional quality in explaining the link between CO_2 emissions and income. However, it seems that the results obtained are inconsistent. Therefore, re-examination of the relationships based on stages of development of countries is required so that policy makers of both developed and developing countries are able to design appropriate policies aiming for better growth without giving up on environmental quality.

The study began with the discussion of the recent issues regarding the emissions of CO_2 in both developed and developing countries. The figures that show a comparison between developed and developing countries in terms of CO_2 emissions per capita and total CO_2 emissions are also presented. In addition, there are discussions on the role of institutional quality in stimulating growth, and how does it influence the link between CO_2 emissions and income.

Chapter Two presents the contributions made by previous researchers on the CO_2-income nexus. In particular, it discusses some related issues regarding the impact of economic growth on CO_2 emissions. The discussion covers issues such as different patterns of Environmental Kuznets Curve (EKC), reasons for varying shapes of EKC and the criticism on the EKC. Besides, this chapter also discusses how factors such as exports, foreign direct investment, institutional quality affect economic growth. In addition, a review of the past studies on the association between CO_2 emissions, institutional quality and economic growth is also highlighted in this chapter. In short, this chapter contains an extensive list of researchers, their methodologies, empirical models, and findings as well as controversial issues in explaining the CO_2-income nexus in an in-depth manner.

Chapter Three discusses the construction of two theoretical models applied in this study, namely the EKC model and the growth model following Demetriades and Law (2006) and Tamazian and Rao (2010), respectively. The chapter also provides the reasoning for the selection of all dependent and explanatory variables. Besides, a variety of panel unit root tests in examining the properties of the series have also been presented in this chapter. Next, a detailed discussion on GMM panel data regression used with the aims of meeting the objectives of the study has been provided. The last section highlights the data sources and the countries selected for the purpose of the study.

Chapter Four reports the results for the impact of income on CO_2 emissions with the presence of three additional regressors, namely trade openness, foreign direct investment, and institutional variables in various groups of countries based on World Bank income classification for the period between 1989 and 2008. In particular, the existence of the inverted U-shaped relationship between income and CO_2 emissions has been examined. Several principal results have been obtained from this chapter.

It is found that the inverted U-shaped relationship between income and CO_2 emissions is confirmed for high income countries indicating that environmental quality may improve "automatically" as income increases. As expected, the inverted U-shaped relationship is in line with some previous studies. As countries get richer, they experience structural change in the economy towards less polluting sectors and at the same time adopt cleaner technologies that help to reduce pollution. For the developing countries, a U-shaped link exists between income and CO_2 emissions implying that CO_2 emissions may continue to increase as income grows higher. Specifically, at very low levels of income, CO_2 emissions tends to decline and as income increases to a certain level, CO_2 emissions start to rise due to industrialization in these countries.

When it comes to the influence of foreign direct investment on the income-pollution nexus, the results obviously show that a positive relationship between foreign direct investment and CO_2 emissions does exist in both the high and upper middle income countries. This result is in line with the notion that foreign direct investment encourages more economic activities that lead to environmental degradation (Grimes & Kentor, 2003; Jorgenson, 2007). In the lower middle and low income countries, however, foreign direct investment has a negative effect on CO_2 emissions. In these countries, foreign direct investment stimulates the adoption of greener technologies that might have led to rapid improvement in energy efficiency and in turn causes a reduction in CO_2 emissions which is consistent with many of the previous studies such as Mielnik and Goldemberg (2002). In the case of lower middle income countries, foreign direct investment has caused a change in the shape of EKC from U to inverted U-shaped.

The estimation results on the impact of trade openness on CO_2 emissions suggest that there is a positive and significant relationship between the two variables in the developed countries. This phenomenon occurs due to the fact that positive scale effect remains stronger than the negative composition and technique effects. Besides, international trade induces higher consumption on goods and services that might have led to an increase in CO2 emissions. On the other hand, however, the analysis for the developing countries indicates that trade openness has a negative and significant impact on CO_2 emissions. Based on the result, it is apparent that upper middle, lower middle, and low income countries are benefited significantly by the transfer of cleaner technologies from developed countries. Besides, CO_2 emissions decrease because the developing countries have been forced to utilize their resources more efficiently in response to stiff competition created by international trade. The role of trade openness in reducing CO_2 emissions is particularly important in upper middle and lower middle income countries in the sense that it helps to generate an inverted U-shaped EKC.

Moreover, the estimated coefficients on law and order are negative and statistically significant in all income groups except low income countries. The results suggest that law and order is an important factor contributing to a cleaner environment in most of the countries in the world. It is particularly essential in upper middle and lower middle income groups in the sense that law and order has helped to turn the EKC into inverted U shaped from the initial U-shaped. In the case of low income group, however, a positive relationship exists between the variables due to weak compliance and poor enforcement of environmental laws.

The impact of corruption on CO_2 emissions is seen to be negative only in the case of high income countries. This indicates that as corruption reduces, CO_2 emissions decreases as well. However, in other income groups, the coefficient on corruption is positive and significant, implying that greater corruption leads to a cut in CO_2 emissions. This result obtained is rather interesting since it seems that corruption can serve as a remedy for pollution in developing countries. In reality, however, the actual amount of CO_2 emissions might not have reduced. Rather, it is merely an underestimation of CO_2 emissions due to underreporting.

A negative and significant relationship is found between the overall institutional quality (measured by the composite index) and CO_2 emissions in most of the income groups. Exception occurs in the low income group where the coefficient is revealed as negative, but not significant. Most importantly, the overall institutional quality plays a vital role in controlling pollution particularly in upper middle and lower middle income countries because it causes a change in the shape of EKC.

To conclude, the results emerged in this chapter are mixed depending on the stages of economic development of countries. This suggests that policy makers of different groups of countries have to design and implement varying public policies in handling environmental problems while maintaining high economic growth.

Chapter Five discusses the role of institutional quality in explaining the relationship between CO_2 emissions and economic growth in different income groups, namely high income, upper middle income, lower middle income and low income countries for the period 1989 to 2008. Besides, the extent to which some factors such as CO_2 emissions, institutional quality, exports and foreign direct investment in influencing economic growth based on different income groups are also examined. Several important results and implications are reported.

First, it is revealed that the impact of CO_2 emissions on economic growth varies according to the stage of economic development. CO_2 emissions have a positive effect on economic growth in high income countries, indicating that pollution caused by industrialization process has led to higher income growth in the developed world. However, CO_2 emissions and economic growth are negatively linked in upper middle income, lower middle income and low income countries. The result suggests that economic growth can be adversely affected by CO_2 emissions due to reduction in productivity of man-made capital and labours in developing countries. Due to the different results obtained, it can be recommended that different policies are required in developed and developing countries to ensure sustained economic growth while maintaining good environmental quality.

The chapter also discovers that law and order, as one of the institutional variables applied has a positive and significant impact on economic growth in all income groups, except low income and lower middle income countries. The results found in the poorer groups of countries are insignificant, showing that there is lack of enforcement and compliance for law and order in these countries as suggested by Jalilian et al. (2006). In other words, law and order plays a significant role in encouraging growth only in high income and upper middle income countries.

However, it is found that degree of corruption and economic growth are positively related in all income groups except upper middle income countries. Instead of "sanding the wheels" as what happens in upper middle income countries, the results indicate that corruption has helped to "grease the wheels" in other income groups. Interestingly, it is also discovered that corruption plays a more important role in explaining growth as compared to law and order in all income groups based on the value of coefficients estimated. Therefore, it is suggested that countries should place more emphasis on dealing with corruption than establishing law and order in the aim of stimulating economic growth. When it comes to the composite index of institutional quality, it has a positive impact on economic growth in both the developed and less developed countries.

It can also be found from the chapter that CO_2 emissions contribute to a favourable impact on economic growth with the presence of proper institutional quality in all income groups. This is proven by the results obtained with the inclusion of interaction terms between CO_2 emissions and various institutional variables. This suggests that the aims of both high economic growth and good environmental quality can be achieved with the availability of proper institutional quality. However, it should be highlighted that corruption must not be used as a tool to achieve economic growth in high, lower middle and low income countries. Instead, resources should be allocated to more productive activities such as education to encourage growth. On the other hand, by looking at the interaction terms in the developing countries, it can be noticed that the coefficient for CO_2 emissions has changed from negative to positive showing that complementary effects do exist between CO_2 emissions and institutional variables on economic growth. This finding further suggests the importance of institutional quality in contributing to high growth and clean environment, in the developing world.

When exports and economic growth are concerned, the results show that exports have a positive effect on economic growth in all income groups, except low income countries. For low income countries, exports lead to a decline in economic growth, instead. This result is not surprising due to the fact that poor countries may have to face problems such as unequal terms of trade and unstable global market.

The finding also reveals that only high income and upper middle income countries are benefited from foreign direct investment. In lower middle and low income countries, however, FDI causes deterioration in economic growth. The positive impact of FDI on economic growth in richer countries is in line with previous studies who suggest that FDI tends to facilitate the transfers of technologies and management know-how into host countries. However, low income and lower middle income countries are not able to benefit from FDI due to their absorptive capability such as less efficient pool of human capital, financial system, trade policy and formal institutional frameworks.

It can be concluded that CO_2 emissions, institutional variables, exports and foreign direct investment are found to have varying impacts on economic growth in different income groups. Therefore, the policy makers of different income groups need to take the differences into consideration and establish the right policies to ensure continuous economic growth without sacrificing the environment.

6.3 Policy Recommendations

A number of important policy recommendations can be derived from this study. First, it is vital for the policy makers in the high, upper middle and lower middle income countries to adopt appropriate monetary policy in maintaining low level of inflation. To ensure sustainable economic growth, various measures such as inflation targeting and fiscal responsibility laws should be considered in keeping the inflation low and stable. With price stability, financial sector in these countries will tend be to more stable, helping to boost the activities related to capital formation in the economy that can in turn lead to higher economic growth. On the other hand, for low income countries, as higher inflation rate is consistent with higher economic growth rate, thus keeping a moderate level of inflation is required. Thus, government policies such as monetary policy should be adopted to maintain an inflation rate that contributes to higher economic growth, but not to the extent of leading to the phenomenon of hyperinflation.

Second, the fact that an inverted U-shaped EKC exists in high income countries implies that growth is beneficial to the environment over time as income increases. Thus, it seems that policy prescription for reducing pollution in high income countries may merely involve stimulating economic growth. In other words, enhancing growth alone is all that required to overcome the problem of environmental degradation. Since growth seems to be the best 'policy strategy' to curb pollution, then it is vital for the policy makers of high income countries to design growth-oriented policies and strategies in order to reduce CO_2 emissions continuously in these countries. These growth-oriented policies and strategies should include keeping the current investment policies, and at the same time maintaining a good institutional quality. Besides, the policy makers in rich countries have to come out with growth–oriented fiscal and monetary packages as an extra effort to further stimulate economic growth. With higher real per capita income, there would be "automatic" switch towards information-based industries and services, improved environmental awareness, enforcement of stricter environmental laws, and adoption of clean technologies, which lead to lower pollution.

However, for the upper middle, lower middle, and low income countries, the inverted U-shaped does not hold. Instead, CO_2 emissions increase with higher income, suggesting CO_2 emissions will not reduce naturally with economic growth. The main reasons are that environmental governance mechanism and policies are not sound enough and most technological progress is not aimed at improving environmental quality in developing countries. For instance, according to a report by OECD (2012), even though national environmental strategies do exist in most of the developing countries, the green growth framework has rarely been addressed in the mainstream economic policies. The report also highlighted that even the basic green technologies such as in the field of energy efficiency are still lacking in developing countries.

The result further implies that simply waiting for the natural arrival of the turning point as suggested by EKC hypothesis does not seem to be a feasible solution for the developing countries to reduce CO_2 emissions. Therefore, there is a strong need for the policy makers of these countries to develop more stringent environmental policies and incorporate them into the mainstream economic policies to combat pollution problems while stimulating economic growth at the same time. Besides, the policy makers should encourage the use of greener technologies in industries that can be transferred from developed countries. The governments should also consider carrying out economic restructuring to reduce the amount of energy-intensive industries in the economy as currently advocated by some of the developing countries such as China. In addition, education for sustainable development should be implemented so that environmental awareness can be created among the people. With all these measures and efforts taken, it is hoped that the turning point will arrive early at a lower level of income, instead of waiting for the turning point to reach automatically.

Third, policy makers of high income and upper middle income countries are required to be more cautious in designing FDI-related policies since FDI has an adverse effect on environmental quality. In this case, for example, the policy makers need to be more selective in the sense that only those more environmentally friendly FDI are welcomed. In particular, the transfer of environmentally sound technologies (EST) should be set as a prerequisite for the entry of foreign firms into the developed and upper middle income countries. Environmentally sound technologies (EST) are those technologies that create less pollution to the environment, utilize resources in a more efficient manner, and recycle and handle wastes in a more acceptable manner than conventional technologies. To encourage the transfers of EST, governments must put in place certain policies such as adequate environmental laws and enforcement, low trade barriers, proper intellectual property regimes, and sound financing system. These policies can act as main drivers in attracting more environmentally friendly FDI with successful EST transfers. Besides, various incentives such as tax exemption can be granted to those environmentally friendly investment projects. With such measures, only then, the simultaneous goals of robust growth and good environmental quality can be achieved.

In contrast, for both lower middle and low income countries, FDI is found to be beneficial to the environment, indicating that these countries have been focusing on eco-friendly FDI projects. Even though FDI helps to reduce CO_2 emissions, it does not mean that the countries need not to be selective in terms of FDI selection. Instead, they should continue to focus on only environmentally friendly FDI that uses green technologies and consume a low level of resources and energy to avoid following the footsteps of high and upper middle income countries. In other words, the governments of lower middle and low income countries should strive to encourage more eco-friendly capital inflows so that CO_2 emissions can be reduced. However, before this can be done, it is essential for these poorer countries particularly low income countries to enhance its domestic growth mechanisms such as human capital, technologies, institutions, and local financial markets, perhaps through the international development assistance programs. Only with these conditions, FDI will be able to promote economic growth and reduce CO_2 emissions simultaneously in these countries.

Fourth, in the formulation of trade policies, the governments of developed countries must attempt to take into account of both economic development and environmental quality rather than just focusing on economic growth. Even though trade activities lead to growth, these activities also cause environmental problems. Thus, it is necessary for the policy makers of developed countries to integrate environmental concerns as part of their trade policies. In such a case, trade policies have a role to play in actively supporting only environmentally friendly trade. For instance, the promotion of environmental goods and services (EGS)[41] through trade should be further enhanced by measures such as reduction or elimination of tariffs and non-tariffs barriers. On the other hand, trade openness tends to reduce CO_2 emissions in the developing world. Hence, international trade activities can be promoted more extensively by the policy makers in all the upper middle, lower middle, and low income countries with less concern on CO_2 emissions as trade is beneficial to the environment. Nevertheless, continuous efforts must be carried out by the developing

[41] Environmental goods and services (EGS) are able to produce a win-win outcome for trade and the environment. They include clean technologies, goods and services that reduce environmental risks and minimize the use of resources.

countries to ensure a long lasting mutually supportive relationship between trade and the environment. This can be achieved by promoting transfers and adoption of clean technologies, and lifting the trade barriers for environmental goods and services. However, exports lead to lower growth in low income countries, indicating that rather than putting efforts in developing export-oriented industries, priority should be given to other factors such as small enterprises, better education, domestic investment that might have been contributing to economic growth in these countries.

Fifth, the positive impact of CO_2 emissions on economic growth implies that an increase in CO_2 emissions induces economic expansion. However, this does not mean that emission is an appropriate tool that can be utilised to obtain higher growth. Instead, the governments in the developed world should attempt to embrace the concept of green economic growth, a strategy for countries to realise sustainable development. Thus, it is suggested that the developed countries should seriously consider using less polluting alternatives such as solar and wind power rather than fossil fuel if they want to achieve sustainable growth in the future. Also, it is recommended that a system of tradable pollution permit should be established and implemented so that those developed countries who would like to pollute can buy the permits from the developing world. However, a global pollution monitoring and control agency is required to ensure the success of such a system. The main challenge of the implementation of the pollution permit system is expected to come from the developing countries who are most likely reluctant to give up their opportunities to develop and industrialize in exchange of payments from the sale of permits. On the other hand, for developing countries, the impact of CO_2 emissions on economic growth is found to be negative, showing that economic growth declines as environmental degradation worsens. Thus, it is suggested that appropriate measures must be taken to tackle the problem of negative externalities caused by pollution that result in poor human health and low productivity in these countries. For instance, public policy can play an important role in granting incentives for the employers to use less polluting technologies and to allocate more resources in protecting the health of workers.

Sixth, since institutional quality leads to economic growth and reduced CO_2 emissions in almost all income groups, policymakers should improve the quality of institutions (such as enhancing law and order, curbing corruption, improving bureaucratic quality, increasing democratic accountability, and reducing ethnic tensions) to realize sustainable growth in these countries. Starting from 1990s, there has been increased efforts in carrying out institutional reform activities particularly in developing countries based on the belief that institutional quality does matter for economic growth. However, the track records of success for these reform activities are rather disappointing in most of the cases. This implies that countries should accelerate their efforts further in ensuring the success of institutional reforms. The recent reforms on law and order, for instance, have paid too much attention on initiatives such as reducing case backlog and enhancing judicial independence. Rather, it is suggested that more emphasis should be placed on the enforcement and compliance of the law itself. In other words, legal reforms should also involve making the law-enforcing entities such as environmental protection agencies and police force more effective and efficient. This is particularly relevant and important to the lower middle and low income countries with poor enforcement and compliance.

It is also suggested that governments should place more emphasis on controlling the degree of corruption rather than improving law and order as corruption is found to be the more important factor leading to better economic performance in all countries. This is particularly true for upper middle income countries where corruption and economic growth are found to be negatively related. Corruption activities can be discouraged through measures such as provision of education, high level of employment opportunities, and fair income distribution. The exception occurs in low income, lower middle and high income countries where corruption and economic growth are positively associated. However, it does not mean that policy makers of these countries should rely on corruption as a means to achieve better economic growth. Instead, resources should be allocated to other productive activities such as promoting FDI and exports that can also help to enhance economic growth.

Despite the fact that corruption leads to better environmental quality in the developing world, it is not recommended that corruption is used as a tool to curb pollution. However, the side effects of corruption on the environment need to be taken into account. In these countries, higher corruption simply means underestimation of the actual amount of pollution since some polluting activities have moved underground. If the problem is not recognized, then there will be possibility for the policy makers to make erroneous policy decisions. Once the emissions in the unreported sectors are recognized, appropriate policies can be designed and implemented to overcome the pollution problem in a more effective manner. For the developed countries, on the other hand, a reduction in corruption leads to a cleaner environment, suggesting that these rich nations should continue on with their efforts in cutting corruption to a minimal level. From the above, it can be concluded that curbing corruption should be taken as the policy priority of all countries, both rich and poor, in achieving sustainable growth in the future. Thus, it is recommended that countries should adopt various anti-corruption initiatives such as establish anti-corruption agencies, strengthen financial management, provide incentives for competitive public service delivery and enhance awareness among the public and officials, to eliminate corruption.

Overall, it can be said that institutional quality plays a crucial role in contributing to a favourable relationship between CO_2 emissions and economic growth in all income groups. Thus, it is essential for policy makers of all countries to strengthen all forms of institutions (except corruption) so that the aims of high economic growth together with clean environment can be achieved. However, the reforms take time and a long term commitment is required. In certain countries, it may be difficult due to political reasons in the short run, but in the long run, the results can be very fruitful economically. It is also suggested that the domestic improvement in institutions should be complemented by international coordination and cooperation among countries particularly in handling regional or global environmental issues that may also affect the economic growth of individual countries. In short, in order to achieve a more sustainable future for the world, all countries need to develop a better institutional environment, to implement the right policy mix and to further strengthen cooperation to ensure sustained economic growth accompanied by excellent environmental quality.

6.4 Limitations

The exclusion of some of the other institutional variables such as level of democracy, property rights, political stability (as in Angelopoulos et al. 2010; Claessens & Laeven, 2003; Rodrik , 2000) in the growth model can be considered as one of the limitations of this analysis. These institutional variables are not considered due to the fact that the data is not available. Besides, the data for all the institutional indicators used in this study is obtained solely from the International Country Risk Guide (ICRG) – a publication of PRS Group. Due to financial constraint, other reliable data sources such as Business International (BI) and Governance Indicators ('KKZ indicators') [42] have totally been ignored.

Moreover, this study focuses only on linear panel data analysis due to the complication of statistical software used. In practice, panel data models are often assumed to be linear for convenience sake. According to Lee (2013), many economic theories indicate a nonlinear relationship instead of a linear functional form. For instance, some existing literature such as Liu and Stegnos (1999) and Montfort and Bijleveld (2004) have questioned the assumption of linearity and applied nonlinear panel data analysis in their studies. Thus, the exclusion of nonlinear panel data analysis is one of the limitations of this study.

In addition, this study has applied the first-differenced General Method of Moments (GMM) panel data estimator instead of the system-GMM estimator which

[42] Kaufmann, Kraay and Zoido Lobaton first developed the indicators in 1999 and the data has been updated once in two years.

generally produces more reasonable estimates of the autoregressive dynamics. It is due to the fact that the current econometric software (E-Views) available is unable to support the use of the system-GMM approach.

Besides, the current econometric software (E-Views) applied has the limitation whereby the serial correlation tests are not able to be performed and reported as diagnostic checks.

Another limitation is that the time period covered in this study is from 1989 to 2008 only based on data availability. It is because the latest dataset for some countries and variables is not available.

6.5 Directions for Future Researches

Several suggestions for future researches can be put forth in regards to the examination of the pollution-economic growth nexus. First, it is important for future studies to take other institutional variables such as property rights and level of democracy into consideration and compare their results with major findings in this study. Moreover, instead of obtaining institutional data merely from the International Country Risk Guide (ICRG), it might be insightful for future researches to consider other reliable institutional data sources such as Business International (BI).

Second, in addition to panel data analysis, future researches may consider applying nonlinear panel analysis in their studies so that better insights of the relationship between CO_2 emissions and economic growth can be obtained. According to Honore (2013), the use of nonlinear panel data models are particularly appropriate in the case with a large number of individuals (N) and time periods (T). Even though some efforts have been devoted into this direction, studies using nonlinear panel analysis are still limited.

Third, the adoption of system-GMM methodology will be possible in future researches if the latest version of econometric software is made available. According to Blundell and Bond (1998), the problem of finite sample biases as a result of using first-differenced estimator in autoregressive models with persistent series can be significantly reduced by using system-GMM. With system-GMM, the estimation of a system of equations in both first-differences and levels is done. In this case, lagged first-differences of the variables become the instruments in the level equations.

Fourth, the application of other econometric software such as STATA in future researches may help to examine the serial correlation problem in panel GMM estimates using the Arellano-Bond test for first- and second-order autocorrelation in first differenced errors.

Fifth, future researches may employ the latest dataset from time to time as an attempt to improve on the estimates so that a more updated scenario on the relationship between pollution and economic growth can be obtained.

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Appendix A: Institutional Variables

Variable	Index Value	Definition[43]
Law and order	0-6, higher values= better law and order	Equal weights are given to two separate components, namely “law” and “order”. Each sub-component comprises zero to three points. The “law” sub-component measures the strength and impartiality of the legal system, and the “order” sub-component assesses the popular observance of the law.
Corruption	0-6, higher values=less corruption	A measure of corruption within the political systems that can distort the economic and financial environment, reduce the efficiency of government and businesses by enabling people to assume positions of power through patronage rather than ability, and introduce inherent instability into the political process.
Ethnic tensions	0-6, higher values=less ethnic tensions	A measure of tensions attributable to racial, nationality, or language divisions. Low ratings indicate high tensions due to intolerant and unwilling to compromise among groups.

[43] Refer to http://www.prsgroup.com/icrg.aspx

Democratic accountability	0-6, higher values=better democratic accountability	A measure of the degree of government responsiveness to its people, not just whether there are free and fair elections. The possibility that the government will fall is higher if it is less responsive.
Bureaucratic quality	0-4, higher values=better bureaucracy quality	Assesses the institutional strength and quality of the civil service. It refers to autonomy from political pressure, strength, and expertise to govern with no drastic changes in policies or disturbances in government services. Includes the availability of an established system for recruitment and training of bureaucrats as well.

Source: International Country Risk Guide (ICRG), PRS Group.

Appendix B: Variables, Data Sources and Definitions

Variable	**Data Source**	**Definition**[44]
Real GDP per capita (GDP)	World Development Indicators, World Bank	GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant (2000) U.S. dollars.
Capital stock (CS)	World Development Indicators, World Bank	Gross fixed capital formation (GFCF) (formerly gross domestic fixed investment) includes land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales, and "work in progress." Capital stock is generated using a standard perpetual inventory model based on GFCF.
Inflation, consumer prices (annual %) (INF)	World Development Indicators, World Bank	Inflation as measured by the consumer price index reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly. The Laspeyres formula is generally used.

[44] Refer to http://data.worldbank.org

Carbon Dioxide Emission (CO)(metric tons per capita)	World Development Indicators, World Bank	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.
Exports (X)	World Development Indicators, World Bank	Exports of goods and services represent the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments.
Trade Openness (TO)	World Development Indicators, World Bank	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product.
Foreign direct investment (FDI)	World Development Indicators, World Bank	Foreign direct investment are the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. The indicator is calculated as a ratio to GDP.
Institutional Quality (IQ)	International Country Risk Guide (ICRG) - a monthly publication of The Political Risk Services (PRS) Group	Indicators used to reflect the institutional quality are as follows: i) Law and order ii) Corruption iii) A composite index that measures institutional quality from five perspectives: Law and order, Corruption, Ethnic tensions, Democratic accountability and Bureaucratic quality

Appendix C: Countries Selected based on World Bank's Income Group Classification 2010 [45]

Classification	Countries	Total
Low Income	Bangladesh, Burkina Faso, Ethiopia, Gambia, Guinea-Bisau, Kenya, Liberia, Madagascar, Malawi, Mali, Mozambique, Niger, Tanzania, Togo, Uganda, Zimbabwe.	16
Lower- Middle Income	Angola, Armenia, Bolivia, Cameroon, Congo,Rep., Cote d'Ivoire, Egypt, Arab Rep., El Salvador, Ghana, Guatemala, Guyana, Honduras, India, Indonesia, Moldova, Mongolia, Morocco, Nicaragua, Pakistan, Papua New Guinea, Paraguay, Philippines, Senegal, Sri Lanka, Syrian Arab Republic, Ukraine, Vietnam, Yemen, Rep., Zambia.	29
Upper- Middle Income	Albania, Algeria, Argentina, Botswana, Brazil, Bulgaria, China, Colombia, Costa Rica, Dominican Republic, Ecuador, Gabon, Iran, Islamic Rep., Jamaica, Jordan, Malaysia, Mexico, Panama, Peru, Romania, Russian Federation, South Africa, Suriname, Thailand, Tunisia, Turkey, Uruguay.	27
High Income	Australia, Austria, Bahamas, Bahrain, Canada, Cyprus, Denmark, Finland, France, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Kuwait, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Saudi Arabia, Singapore, Spain, Sweden, Switzerland, Trinidad and Tobago, United Kingdom, United States	31
Total		**103**

Notes: Due to operational and analytical purposes, the World Bank categorises countries as low-income, middle-income and high-income that can further be grouped into developing and developed countries. The classification is done based on 2010 gross national income (GNI) per capita, calculated using the World Bank Atlas method. The low, lower-middle and upper-middle income countries are considered as developing countries. As of 1 July 2011, low-income economies represent countries with average incomes of $1,005 or less. The lower- middle income and upper-middle income countries refer to those economies with the ranges of average incomes $1,006-$3,975 and $3,976-$12,275, respectively. Developed countries are economies with average incomes of $12,276 or more.

[45] Income group classification can be obtained from http://data.worldbank.org/about/country-classifications

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