AN EMPIRICAL EXAMINATION OF ENVIRONMENTAL KUZNETS CURVE (EKC) IN WEST AFRICA

(1980 – 2012)

BY

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10AF010509

A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF ECONOMICS

AND DEVELOPMENT STUDIES,

COVENANT UNIVERSITY,

OTA, OGUN STATE

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARDS OF THE BACHELOR OF SCIENCE (HONOURS) DEGREE IN ECONOMICS

MARCH, 2014

CERTIFICATION

It is hereby certified that this Research Project was written by Oshin Simisola Olubukola and was supervised by Mr. A.A Ogundipe and was submitted to the Department of Economics and Developmental Studies, Covenant University, Ota, Ogun State, Nigeria.

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DEDICATION

This piece of literature is dedicated to God Almighty who has always been my rock, pillar, help and support throughout my life. I also dedicate this work to my parents for their constant love, prayers and support.

ACKNOWLEDGEMENTS

First and foremost, I would sincerely acknowledge the Lord Almighty for giving me the strength and the grace to complete this research work.

My utmost gratitude also goes to the Chancellor of Covenant University, Dr. David O. Oyedepo for the blessings he has showered upon my life, his prayers, his preaching and his words of encouragement which have all enriched my life for a glorious destiny.

I am most grateful to my wonderful parents; Mr. and Mrs. Oshin for their selfless support throughout the years and relentless investment my life academically, financially, spiritually and morally. I want to use this medium to say thank you for all your love, care and encouragement. I pray that God crowns your efforts with success and make you reap the fruits of your labour. I love you mum and dad.

My deep and utmost gratitude goes to my supervisor, Mr. A.A Ogundipe for seeing me through this research project with constructive guidance and advice for constant improvement and above all for his ever-ready attitude to help. I deeply appreciate your efforts Sir.

I would also duly acknowledge all my departmental lecturers for the help, guidance and support. I appreciate Prof. Alege for continuously motivating us, and for his impact on the department. I acknowledge Prof. Olurinola, Dr. Ewetan, Dr. Urhie, Mr. Oluwatobi, Mr. John, and Dr. Campbell whom before she left the department was an inspiration to me. Thank you all for instilling knowledge and discipline in me.

This will not be complete without acknowledging my wonderful siblings, Damilola Oshin and Babasanjo Oshin, for their love and words of encouragement throughout the course of this research study. You guys are the best siblings ever. I love you.

I can't forget those who have made life so wonderful to live in one way or the other, my dear course mates and friends, Feranmi, Dolapo, Makuo, Omobola, Seyi and so many others. Words cannot adequately express how much you have blessed my life. I appreciate you all. Thank you so much.

Oshin Simisola

June 2014.

TABLE OF CONTENTS

Title page ……………………………………………………………………………………i

Certification………………………………………………………………………………….ii

Dedication……………………………………………………………………………….....iii

Acknowledgements…………………………………………………………………………iv

Tables…………………………………………………………………………………….....ix

Abstract……………………………………………………………………………………..x

CHAPTER ONE: INTRODUCTION

1.1 Background to the Study ……………….……..………………………………………. 1

1.2 Statement of Research problem ……………...………………………………………. 4

1.3 Scope of Study ………………………………………………………………………. 5

1.4 Research Questions .....……………………..……………………………………….6

1.5 Objectives of the Study ………………………………………………………....... 6

1.6 Research Hypothesis ……………………...………………………………………... 6

1.7 Significance of the study………………………………………………………………7

1.8 Research Methods …………………………………………………………….............8

1.9 Data Sources ……………….………………………………………….……………..8

1.10 Outline of Chapters ……………………………………………………………………9

CHAPTER TWO: LITERATURE REVIEW

2.1 Conceptual Review …………………………………………………………………….12

2.1.1 Environment ………………………………………………………………………... 12

2.1.2 Pollution ………………………………………………………………………………. 12

2.1.3Environmental quality……………………..………………………………………….13

2.1.4 Economic growth ………………………………………………………………… 13

2.2 Theoretical Issues…………………………………………………………………………….14

2.3 Environmental Improvement Channels……………………………………………………...17

2.3.1 The scale effect…………………………………………………………………………….17

2.3.2 Composition effect…………………………………………………………………………20

2.3.3 Technology effect…………………………………………………………………………….22

2.4 Empirical and Methodological review……………………………………………………….24

CHAPTER THREE: THEORETICAL FRAMEWORK AND RESEARCH METHODOLOGY

3.1 Introduction …………………..…………………………………………………………….. 29

3.2 Theoretical Framework ……………………………………………………………………...29

3.3 Research Methodology……………………………………………………………………30

3.3.1 Model Specification ………………………………………………………………......31

3.3.2 A priori Expectations ……………………………………………………..................33

3.3.3 Technique of Estimation…………………………………………………………….33

3.3.4 Sources of Data and Measurement……………………………………………….35

CHAPTER FOUR: EMPIRICAL RESULT AND ANALYSIS

4.1 Introduction ……………………………………………………………………………37

4.2 Summary Statistics ……………………………………………………………………… 38

4.3 Econometric Analysis…………………………………………………………………..40

4.3.1 Correlation matrix……………………………………………………………………40

4.3.2 Panel Data Analysis …………………………………………………………………40

4.4 Discussion of Results……………………………………………………………………...43

4.5 Findings and Economic Interpretation of Results………………………………………..46

4.6 Conclusion…………………………………………………………………………….. 48

CHAPTER FIVE: SUMMARY, RECOMMENDATIONS AND CONCLUSION

5.1 Summary ………………………………………………………………………………….50

5.2 Recommendations ……………………………………………………………………...51

5.3 Conclusion ………………………………………………………………………………52

5.4 Limitations of the study ……………………………………………………………….52

5.5 Suggestion for further studies………………………………………………………….53

REFERENCES……………………………………………………………………………..54

APPENDIX…………………………………………………………………………….56-65

LIST OF TABLES

Table 3.1: ………………………………………………………………………………...36

Table 4.1: …………………………………………………………………………………38

Table 4.2: …………………………………………………………………………………43

ABSTRACT

This study focused on the empirical examination of Environmental Kuznets Curve (EKC) in West Africa and tried to discover whether or not the EKC held in West Africa for carbon emissions (CO_2) which is an indicator of environmental quality. The study included the entire sixteen countries located in the West African region and spanned the time period from 1980-2012. The panel data estimation technique was carried out and the result generated from our analysis was that of the fixed effects estimation. The results generated also concluded that there is the presence of EKC in West African countries for the carbon emissions indicator of environmental quality. Improvement in the quality of education in West African countries was discovered to be one of the policies which could help reduce environmental degradation in the West African region.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

The term Environmental Kuznets Curve (EKC) has its roots in the time-series pattern of income inequality which was described by Simon Kuznets in 1995(Richmond and Zencey, 2007). The EKC concept is a modern development in environmental economics especially with the ground breaking study embarked upon by Grossman and Krueger (1991) when examining the environmental impacts of the North American Free Trade Agreement (Bhattarai and Hammig, 2001). The Environmental Kuznets Curve (EKC) hypothesizes that there exists a relationship between environmental degradation and per capita income of countries. At the point in time when economic growth begins to take place, degradation and pollution would rise but a level of income per capita is then reached (this level of income per capita would vary for different indicators of environmental quality) and the prevailing pattern reverses so that at a high income level, economic growth would lead to improved environmental quality (Stern, 2003).

The EKC originated from the inverted U – shaped income distribution of Simon Kuznets (1955) which is known as Simon Kuznets Curve. The Kuznets curve explained the relationship between inequality and per capita income of countries. Simon Kuznets postulated that as an economy undergoes economic growth, the level of income inequality at first will be wide, the rich would get richer, and the poor will get poorer. However, when a particular per capita income is reached, the income inequality gap in the nation begins to decline.

In 1991, the Simon Kuznets Curve took a turn and it became a tool for measuring the relationship between levels of environmental quality and per capita income (Yandle, Vijayaraghavan and Bhattarai, 2002). Therefore, the Simon Kuznets Curve which had hitherto been used to measure inequality among countries was now being used to measure level of environmental degradation of countries. Specifically, there is proof to verify that the level of environmental degradation and per capita income follows a similar inverted – U shape as does income inequality and per capita income which is seen in the original Kuznets Curve (Yandle, Vijayaraghavan and Bhattarai, 2002).

Before the discovery of the EKC however, it was widely believed that the industrialized countries destroyed their economies more than the developing countries. This was because the industrialized nations made more use of their natural resources as well as contributed a lot more to the pollution of the environment. Prior to the advent of EKCs, many well informed people believed that the richer economies damaged and even destroyed their natural resource endowments at a faster pace than poorer ones. They thought that environmental quality could only be achieved by escaping the clutches of industrialization and the desire for higher incomes (Yandle, Vijayaraghavan and Bhattarai, 2002).

Environmental pollution or degradation is one of the issues developing countries around the world, especially in Africa are saddled with. Economic growth for most West African countries has not come without a price. For instance in Nigeria, the main source of foreign exchange as well as revenue comes from crude oil. With the constant drilling that goes on in oil-rich areas of the Niger Delta, pollution has become the bane of the people. Gas is burnt on a constant basis, thereby disrupting the atmosphere. Oil spillage has hindered locals of such areas from carrying out their activities on the farm, also the water from the streams are no longer fit for human consumption. According to statistics, Nigeria’s crude oil and gas production between 1973 and 2008 with respect to total GDP has ranged between 21.1 percent and 37.5 percent. Nigeria has contributed immensely to the level of world's environmental degradation since 1961, however in recent years there has been some improvement.

According to Ityavyar and Thomas, as the population of a society increases in size, individual members of the society exert more pressure on scarce available resources such as land, and other natural endowments for survival. Most West African countries started as agrarian economies, but as they attained economic growth, they moved from agrarian societies to industrialized societies. These industrialized societies make use of more resources, thereby putting pressure on the environment. Although economic growth is achieved, it is at the expense of the environment.

Air pollution, noise pollution, natural resource depletion, climate change, deforestation and so many more are all as a result of economic growth in many West African nations. Two main challenges which the African continent has to deal with is the inability to deliver safe drinking water to the constantly teeming population as well as lack of access to sanitation (Omotor and Orubu, 2010).

Also according to Alege and Ogundipe (2013), the EKC statistical relationship suggests that as development and industrialization takes place, damage to the environment increases due to operation of dirty technologies, greater use of natural resources, high pollutant emissions and a bigger desire to increase productivity and levels of output without taking into consideration the resulting negative effects on the environment. Countries are therefore much more concerned with attaining economic growth rather than ensuring environmental safety. Importation and trade openness has also led to dumping in many West African countries. As a result of the fact that economic growth can usually be achieved mainly through import and export of commodities, developed nations take advantage of West African countries by exporting to them products which are substandard in quality which in turn has adverse effects on the environment.

However, as West African nations begin to develop and attain a level of per capita income, they begin to develop and engage more in service oriented industries which reduce the level of pollution activities, thereby bringing about less negative effects on the environment.

1.2 STATEMENT OF THE RESEARCH PROBLEM

A lot of empirical work has been done on the subject of Environmental Kuznets Curve (EKC) over the past years. These works tested for the presence of the EKC in several regions and countries of the world using diverse environmental indicators such as: fresh water quality, carbon emissions, sulfur dioxide, nitrogen oxide and so on. In some cases the EKC statistical relationship between environmental degradation and per capita income held for some indicators of environmental quality in certain countries and in other cases the EKC hypothesis failed to establish a relationship.

The major research problem however which has been observed is that most of the previous work done on the EKC has been conducted majorly in advanced countries of the world and very few in the African continent. The West African region on the other hand, which this study focuses on, has limited empirical studies on the issue of EKC. Some of the works done in advanced countries include that of Bouvier (2004) where the relationship between per capita income and emissions of carbon monoxide, sulfur dioxide, carbon dioxide and volatile organic compounds were observed using data from European and North American countries from the period of 1980 – 1986. Also, a study on the EKC was carried out by Roca, Padilla, Farre and Galletto (2002) and they focused on economic growth and atmospheric pollution in Spain. Again, in a work done by

Bartoszczuk, Ma and Nakamori (2002) and they focused on some developed European countries which included: Austria, France, Belgium, Sweden and Spain from a time period of 1960 – 1996.

In Africa, few works have also been done some of which include that of Orubu, Omotor and Awopegba (2009). The study aimed at establishing a relationship between environmental degradation and per capita income while searching for EKC in some selected African countries. In West Africa, a study was carried out by Omojolaibi (2010) while measuring the relationship between carbon emissions and GDP per capita in some selected West African countries which include: Nigeria, Ghana and Sierra Leone.

The major aim of this study therefore is to add to the existing literature on the EKC and conduct an empirical analysis in order to discover whether the EKC theory holds in the West African region. With the advent of global warming, pollution, atmospheric changes and so on, if the EKC theory holds in West Africa, we expect income to grow and get to a certain threshold and at which point the level of environmental degradation would begin to decline with the corresponding increase in income. Hence with the limited work done in the West African region on the EKC, the aim is to ascertain whether West African countries have reached that stage of the turning point in their per capita income.

1.3 SCOPE OF STUDY

The study covers the entire West African region. It examined the effect of carbon emissions (CO_2) in West African countries. The study was limited to data available from World Development Indicators (WDI) and the World Governance Indicators (WGI) of the World Bank.

1.4 RESEARCH QUESTIONS

This study aims at giving appropriate answers to the following research questions:

1. Is there the presence of Environmental Kuznets Curve in West African countries?
2. What is the relationship between level of environmental degradation and per capita income in West Africa?

1.5 OBJECTIVES OF THE STUDY

The broad as well as overall objective of this study is to examine empirically the EKC in West Africa. The specific objectives of the study include:

1. To examine the relationship between the level of environmental degradation and per capita income of West African countries.
2. To establish if EKC exists for an indicator of environmental quality such as: carbon emissions (CO_2) in West Africa.
3. To examine the effects of institutions, population density, literacy rate and trade openness on the quality of the environment in West Africa.

1.6 Research Hypotheses

1. H_0: There is no significant relationship between environmental degradation and per capita income of West African countries.

   H_1: There is a significant relationship between environmental degradation and per capita income of West African countries.

2. H_0: There is no significant relationship between the per capita income of West African countries and carbon emissions.

H_1: There is a significant relationship between the per capita income of West African countries and carbon emissions.

1.7 SIGNIFICANCE OF THE STUDY

The significance of conducting a study on the empirical examination of environmental Kuznets curve in West Africa therefore would actually go a long way in terms of policy decision making. Hence, testing for EKC has immense policy implications in the sense that its presence or absence would determine the sort of policies that will be formulated by policy makers. Through this study, policy makers in West African countries would be in better positions to formulate and implement policies that would actually be beneficial to the degrading West African environment. This is because of the fact that if EKC in West Africa follows a constant trend, then low levels of environmental quality would only last for a short period of time. Therefore, policy makers would formulate as well as implement policies that would be geared towards increasing the level of economic growth as well as per capita income of countries. Environmental degradation in the long run would be a thing of the past if West African countries reach the peak and obtain a higher level of per capita income. At this stage therefore, more effort will be put into taking care of and enhancing the quality of the environment. Therefore, this study would help policy makers make more informed decisions concerning matters such as: improvement in the level of water availability, improvement in the level of sanitation, reduction in the amount of suspended particulate matter in the atmosphere and so on.

In view of adding to literature, this study will help broaden the current knowledge individuals and scholars alike have on EKC. The literature on EKC as well as the empirical studies on EKC in West Africa has been very scanty; hence this study seeks to simply contribute to the body of knowledge. Also, most variables used to test for EKC have poor statistical properties; therefore, this study aims at using more reliant statistical data in order to give the appropriate econometric results. Therefore, this study would contribute to the already existent empirical knowledge of the EKC.

1.8 RESEARCH METHODS

In this research study, the panel data analysis technique would be made use of. In using the panel data analysis technique, the OLS regression analysis would be carried out as well as the Fixed effects (FE) and the Random effects (RE) tests. The Hausman specification test would also be carried out.

The independent variables captured in the model are: institutions, population density, trade openness and literacy rate. The dependent variable is an indicator of environmental degradation which is carbon emissions (CO_2). The pollution-income model would also be used in the research work. The data is sourced from the World Development Indicators (WDI) and the World Governance Indicators (WGI) of the World Bank.

DATA SOURCES

The data derived for this study were gotten solely from secondary sources. The secondary data sources were gotten from journals, articles and other connected sources which have to do with the subject matter of the Environmental Kuznets Curve (EKC). Some other major data sources include: World Development Indicators (WDI) of the World Bank, as well as the World Governance Indicators (WGI) of the World Bank.

1.10 OUTLINE OF THE STUDY

Chapter two of the study is composed of Literature review. It examines the theories which have been used to explain the EKC relationship as well as the trend of the EKC in various countries of the world. Chapter two also comprises of the EKC hypothesis and how true the theory has held in studies which have been conducted in single countries, West African countries, and African countries as well as developed and developing countries.

Chapter three consists of the Theoretical Framework and Research Methodology. This would include data collection, model specification, model estimation techniques as well as sources of data collection and criteria for decision making.

Chapter four is the Estimation and Results. It deals with the analysis and interpretation of the results derived from the model specification in chapter three.

Chapter five consists of the Summary, Conclusions and Recommendations. Also after this chapter, references, bibliographies and appendixes are also included in the study.

CHAPTER TWO

LITERATURE REVIEW

This constitutes a review of relevant literature and it is comprised of the theoretical framework, conceptual framework, and empirical as well as methodological framework. It also consists of propositions, findings, hypothesis and conclusions of various other scientific works which have hitherto been done and writings related to my research topic.

INTRODUCTION

The Environmental Kuznets Curve initially originated from the Kuznets Curve. The Kuznets Curve states that as a country develops, there is an initial widespread level if inequality which arises among the citizens; however when a particular income level is reached the level of inequality begins to drop. The Kuznets Curve originated from Simon Kuznets and his general postulation was that as nations undergo industrialization, people who have investment opportunities would begin to establish industries and employ cheap labour. The Kuznets Curve also carries an inverted – U shape. According to Richmond and Zencey (2007), the term EKC is founded on the based on the shared characteristics it possesses with the time – series pattern of income inequality which was explained by Simon Kuznets in 1955.

The Environmental Kuznets Curve (EKC) represents the relationship which exists between per capita income in a country as well as the level of environmental degradation. This is the reason why the graphical illustration of the EKC is an inverted – U shape. Richmond and Zencey (2007) state that the Environmental Kuznets Curve assumes that the relationship which exists between per capita income and the use of natural resources or toxic wastes emissions is that of an inverted – U shape. Also, according to Stern (2003) the environmental Kuznets curve is an assumed relationship between environmental degradation and per capita income. Basically, when a country starts to attain some level of economic growth and their income begins to rise, the level of pollution would also begin to rise. However, a turning point is soon reached and this turning point has to do with the income of the country. The turning point signifies a decline in the level of environmental degradation in the country due to an increase in per capita income and an overall improvement in environmental quality. Stern however states that the level of per capita income which would lead to a decline in environmental degradation would vary for the different indicators of environmental quality.

Alege and Ogundipe (2013) also state that the EKC statistical relationship suggests that as development and industrialization takes place, damage to the environment increases due to the operation of dirty technologies, greater use of natural resources, high pollutant emissions and a bigger desire to increase productivity and levels of output without taking into consideration the resulting negative effects on the environment. This simply points to the fact that as an economy undergoes industrialization, they are more concerned about improving their level of economic growth rather than their environment. They make use of any kind or form of means to attain economic growth. However, as the rate of growth increases, the quality of life increases, healthier technologies are made use of, services begin to expand and the environment becomes an object of focus.

2.1 CONCEPTUAL REVIEW

DEFINITIONAL ISSUES

2.1.1 ENVIRONMENT

The role which the environment plays in the development of any nation's economy cannot be overemphasized. The environment does not only serve as a provider of natural habitat, it also lays the foundation for all forms of human exploitation in the agricultural, commercial, industrial, technological and tourist sectors of a society (Ityavyar and Thomas, 2007).

The environment has to do with the natural resources which are deposited on the earth. It consists of natural capital stock such as land, air, water and so on. The environment makes up the natural capital stock of an economy, consisting of all land resources, water resources and the atmosphere which encloses the earth (Orubu, Omotor and Awopegba, 2009). The environment serves a dual purpose in the sense that it gives rise to production and consumption, both of which are economic activities as well as serves as a dumping ground for wastes which might be generated in the process. According to Orubu et.al, the environment provides natural resources which are used in the production of goods and services and also serves as the disposal mechanism where the wastes generated from production and consumption activities are dumped.

2.1.2 POLLUTION

According to Microsoft Encarta 2009, pollution is the contamination of the earth's environment with materials that affect human health, the quality of life or the natural functioning of ecosystems (living organisms and their physical surroundings). The committee on pollution of the Unites States National Research Council (1965) likewise defined pollution as "an undesirable change in physical, chemical or biological characteristics of our air, land and water that may or will harmfully affect human life or that of other desirable species, our industrial processes, living conditions, cultural assets that may or will waste or deteriorate our raw material resources". Hence, from the above definition pollution has a negative impact on the environment, which eventually takes its toll on the economic growth of a nation.

2.1.3 ENVIRONMENTAL QUALITY

Environmental quality is a set of properties and characteristics, of the environment, either generalized or local, as they have an influence on human beings and other organisms. Environmental quality can be seen as a general term which has to do with the natural environment which consists of air, pollution, water purity, noise and so on.

Environmental quality has many dimensions. Our lives are one way or the other influenced by the air we breathe, the water we drink, the beauty we take note of in nature, and the variety of species with which we come into contact (Grossman and Krueger, 1994). Also, according to Los Angeles 2050 (LA2050), the environment where people live, work and play is a very important factor in the quality of there lives. Hence, when quality of life is improved, productivity levels of workers are bound to rise thereby leading to an overall economic growth of the nation.

2.1.4 ECONOMIC GROWTH

Economic growth can be said to be the increasing capacity and ability of any economy to meet the needs and wants of the economy overtime. According to Investopedia, economic growth is an increase in the capacity of an economy to produce goods and services, compared from one period of time to another. Economic growth more often than not affects every area of a country's economy. It is a tangible growth which affects the productivity of a nation as well as increases profit for that nation. Again Jhingan (2010), defined economic growth as “the process whereby the real per capita income of a country increases over a long period of time”. In this vein, economic growth can be said to be determined by several factors. Some indicators of economic growth include: price stability, full employment, balance of payments equilibrium and so on. An economy that is said to have achieved economic growth would produce an increasing number of goods and services in every time period. Economic growth can be measured by the increase in the amount of goods and services produced in a country or the rate of growth of per capita GDP or the rate of growth of GDP. The augmented Solow growth model can be regarded as the foundation for most growth models. It consists of four economic growth determinants which include: population growth, initial income, human accumulation rates and physical capital accumulation rates.

2.2. THEORETICAL ISSUES

Economic growth can be seen as an increase in the total amount of production and wealth in an economy. The main basis of the EKC is that there is an inverted - U shaped curve which shows the relationship between environmental degradation and economic growth. This therefore implies that as income level rises, pollution increases until a turning point or threshold is reached in the nation’s income and pollution then begins to decline. Hence, environmental quality depends on economic growth. A nation that is in its traditional stage will not suffer from adverse effects of pollution like an industrialized nation would. The EKC hypothesis states that the economy of a nation would evolve from an agrarian based economy which has no harm on the environment to a dirty economy characterized by the use of dirty technologies and then back to a service based and knowledge based economy (Alege and Ogundipe, 2013). A country that experiences economic growth would most likely involve itself in international trade.

International trade has its own advantages, however more often than not, trade encourages dumping. This constitutes harmful or dangerous commodities which might be bad for a nation's environment.

When it comes to explaining the EKC, international trade is one of the most important factors. International trade gives countries the opportunity to have access to goods which are not readily available in their own countries. Dinda (2004) states that trade leads to an increased economy as a result of the constant buying and selling which takes place and this in turn leads to increased pollution activities. Therefore, according to Dinda, all things being equal, trade leads to environmental quality degradation. International trade more often than not increases the risk which countries are exposed to in the sense that harmful products could be exported from one country to another thereby causing harm to the nation's environment and increasing pollution levels. Free trade is also said to have mixed impacts on the environment. This is because on one hand, trade could increase pollution through the scale effect, where economic activity increases and the amount of exports also increase simultaneously. However, the quality of the environment can be improved through trade while making use of the scale and composition effect. This is achieved when the income earned from trade is used to improve environmental quality conditions thereby causing a reduction in pollution, Dinda (2004).

The EKC hypothesis is not known to be characterized or backed up by any major theories existent in literature. Hence, we would be examining some of the theories which led to the establishment of the Kuznets Curve, from which the Environmental Kuznets Curve itself originated. According to Syrquin (2005), Simon Kuznets did not believe entirely in mere theoretical facts but rather, he aimed at ensuring that valid empirical evidence should be derived in order for the principles backing up empirical economics to be understood. Also, Syrquin states that there is no formal theory which backs up the Kuznets Hypothesis but there is a lot of theoretical work which has been done in order to understand the empirical evidences that have been brought forward as well as underlying causes of the Kuznets Curve hypothesis. Kuznets was also against the idea of a pure economic theory of growth. He believed rather in a general theory of economic growth (Syrquin).

In modern day economics, several works has been done on Kuznets original hypothesis and this has led to a lot of discoveries due to wider and deeper research work being undertaken. Recently, Kuznets hypothesis was reviewed and this led to widening the theoretical foundation of the Kuznets hypothesis. Sarrigiannidou and Palivos (2012) re - examined the Kuznets hypothesis and came up with a modern theory of the Kuznets hypothesis. According to Sarrigiannidou and Palivos, a lot of effort has recently gone into expanding the theories upon which the Kuznets hypothesis is established. Sarrigiannidou et.al state that the theories which have been brought forward relate in some way to the "trickle – down" theory. The basic explanation of the trickle – down theory is that when there is adequate economic growth and there is minimal intervention in solving the issue of inequality, the benefits of economic growth and development would eventually spread downwards to the poor in the society.

In a study examined by Sarrigiannidou et.al, the trickle – down theory was premised on human capital accumulation and the technological knowledge which could be derived from it. The factors enhancing economic growth here are human capital accumulation and advancement of technology. Technological knowledge is accumulated as a result of individuals investing in their education. Initial investment in human capital is undertaken by the rich in the society since they have the necessary capital to do so. With an increase in human capital, technological knowledge is also increased however, it is concentrated in a small part of the society and in the hands of a few individuals. As time goes on, technological knowledge begins to spread to every member of the society and education is also spread to everyone. Gradually, the economy begins to enter into a cycle of self – declining inequality.

However the basic and underlying assumption of the environmental Kuznets curve (EKC) is that there is an inverted U-shaped relationship between environmental degradation and economic growth. This simply implies that as the per capita income of a nation rises, the level of environmental quality diminishes, but once income passes a certain point, environmental quality begins to rise (Orubu and Awopegba, 2009). Hence, there are a number of factors which explain the reason for the existence of the EKC relationship.

One of the theories backing up the EKC relationship therefore include: The scale, composition and technology effects (Orubu and Awopegba, 2009).

The existing knowledge on the theoretical aspect of the EKC literature was increased with the findings of Grossman and Krueger (1991). Grossman and Krueger pointed out three possible impacts of an increase in the economic activity of a nation due to trade agreement. The first was an increase in the scale of current production; the second was a change in the composition of current production and the third was a shift in production techniques.

2.3. ENVIRONMENTAL IMPROVEMENT CHANNELS

2.3.1. THE SCALE EFFECT

According to Constantini and Martini (2006), when talking about the scale effect, an increased economic activity in a country leads to increased damage in the environment. This is due to the fact that for production activities to increase there will be a greater pressure on natural resources as well as higher pollution due to increased production output. Also, if the structure or technology operated in an economy does not undergo any form of change, for pure growth to occur in the scale of the economy, it would invariably lead to an increase in the level of pollution and other forms of environmental damages. This is referred to as the scale effect (Stern, 2003). This simply means that a growth in the economy of a country would lead to a proportional increase in pollution.

The scale effect naturally leads to a higher level of pollution as a result of as a result of freer trade which leads to economic growth. Countries that operate open economies and allow for trade are more at risk when it comes to pollution of the environment. This is because foreign goods which might be harmful for the environment or to the people will be imported into the country. The scale effect explains the assumption that to increase production, more material and natural resources are needed, but an increase in production almost always leads to more wastes and unwanted products which cause an increase in environmental pollution (Orubu and Awopegba, 2009). Basically the scale effect deals with two forms of environmental pressures - an increased usage of natural resources which leads to resource depletion and an increase in wastes products which leads to environmental pollution. This therefore implies that economic growth which has to do with increasing the scale of production has an adverse effect on the environment. Dinda (2004) states that for output to increase more input is needed, thus more natural resources are made use of in the process of carrying out production activities. More output connotes environmental wastes and an eventual reduction in environmental quality. Therefore according to Dinda, the assumption of the EKC that the scale effect has a negative effect on the environment is over-ruled by the positive impacts of the composition and technology effect. In order for there to be a balance, an increase in output would lead to an increase in the level of environmental degradation. It can be observed that the scale effect occurs mainly in countries that are just experiencing economic growth and have therefore increased their level of output in order to achieve economic growth.

Scholars of the EKC theory support the fact that a scale effect is evident - i.e. an overall increase in the size of the economy which leads to a simultaneous increase in environmental degradation (Bravo and Marelli, 2007). However, they argue that at least three different factors are able to overcome it at higher income levels. These factors are: changes in the output mix, changes in the input mix and technology improvements.

CHANGES IN OUTPUT MIX

Changes in output mix refer to a shift in an economy from an industrial – based economy to a service – based economy. This sort of change occurs mainly in middle – high income countries and it generates a lower negative effect on the environment (Bravo and Marelli, 2007). Since the scale effect usually implies an increase in the use of natural resources, as well as increased pollution effects, countries can avoid having to deal with pollution issues by focusing more on service – based economies rather than industrial – based economies. Engaging in services for any country would reduce the amount of pollution in that country. Since the aim is to increase output to attain increased economic growth, services are the right shift in direction. However only advanced countries that have attained some level of economic growth and development can engage in service – based economies, e.g. USA.

Orubu and Awopegba also state that changes in output mix result from differences in pollution intensities from different industries; which is typical in the course of economic development. This implies that various industries begin to change their input in order to reduce pollution.

CHANGES IN INPUT MIX

This is the means of substituting of less environmental damaging inputs for more damaging inputs, e.g. from coal to natural gas for heating and energy production (Bravo and Marelli). Here, a country attains economic growth by taking a damaging input and converting it to more profit however, this change could be in form of a more damaging input and vice versa.

TECHNOLOGY IMPROVEMENTS

According to Stern (2003), for there to be improvement in the state of technology, changes have to occur in: production efficiency and emissions specific changes in process. Production efficiency requires using less environmentally degrading inputs for every unit of output which is produced, while emissions specific changes in process refers to less pollution emanating from the use of input per unit. Production efficiency simply requires the inputs being used in the production process to be healthy to the environment and not result in pollution in the eventual output. An emissions specific change in process also requires less pollution per unit of input.

Stern (2003) also postulated that as scale, output mix and technology are held constant; this is equivalent to moving along the isoquants of a neoclassical production function.

2.3.2 THE COMPOSITION EFFECT

The composition effect simply applies to the extent of production activities that are carried out in the whole of an economy's output. According to Orubu and Awopegba, composition effect has to do with the relative size of each type of productive activity in the amount of the economy's output. New Palgrave dictionary of Economics also stated that if growth is not equal, but is accompanied by a change in the composition of goods produced, then pollution may decrease or increase with income. This therefore means that if richer economies produce proportionally less pollution - intensive products, because of changing tastes or patterns of trade, then composition effect can lead to a decline in pollution associated with economic growth. When a country is just attaining development, pollution tends to be high as a result of the scale effect, however as they become more technologically advanced, pollution starts to decline. According to Ekins (1997), when development is at its earlier stages, the composition effect tends to strengthen environmental pressures which result from an increasing scale and tends to have a smaller effect at a higher level of development.

Dinda (2004) states that composition effect has a positive effect on the environment reason being that when income rises, the economy's whole structure changes and this brings about a change in the type of technology being adopted, preferably cleaner technologies and this would eventually lead to a decrease in pollution. The structure of the economy changes from an agrarian or rural society to an industrialized or urban society, where pollution activities tend to be higher. With an industrialized society comes another structural change in the where the economy moves from energy – based economy to knowledge based economy and proceeds to commence engagement in services and clean technologies. This goes to show that a composition of the various structural changes an economy undergoes can eventually add up to have an effect on environmental quality which is a positive one.

2.3.3 TECHNOLOGY EFFECT

The technology effect emphasizes countries giving up relatively dirty technologies for cleaner technologies whenever production activities are carried out. Bouvier (2004) states that when the technology effect is in place and countries begin to develop, production activities will be carried out with cleaner technologies as opposed to the formerly used dirty technologies. This would therefore reduce the amount of pollution for every unit of output produced, and at the same time keeping the output mix at the same level. Bouvier also distinguishes between the two types of technology effect. One is the autonomous technology effect while the other is the induced technology response. Bouvier states that the autonomous technology effect is one in which the use of cleaner technologies are made use of immediately for exogenous motives, while the induced technology response is achieved through the decision of both the public and private to reduce pollution levels.

Orubu and Awopegba state that technology effect arises from advancement in the level of technology. This is because of the fact that it is generally assumed that as a country attains development, there technology would also become highly improved. In essence, the technology effect is meant to reduce pollution levels as a result of the economic growth and development which countries would be attaining.

Many other theoretical works have however been added to the EKC hypothesis. In view of this, we would be looking at other theories developed and formulated by scholars over the years with respect to the EKC theoretical literature.

Looking at the theoretical EKC literature from another point of view, two major strands of papers can be distinguished. Both of them concentrate on the technological aspect of the EKC and the reason for the inverted – U relationship. Egli (November, 2005) mentions the two theoretical EKC models.

The first theoretical EKC model is the shift in the use of production technologies while the second theoretical EKC model is the abatement technology.

Now, according to Yandle e.t. al (May, 2002) the EKC statistical relationship indicates that as a country attains states of economic development and industrialization, the level of environmental degradation begins to decline as a result of increased usage of natural resources, increased pollution emissions, more attention given to production of material output and the negligence of the negative effects which growth has on the environment. However, it gets to a point whereby as economic growth continues, a threshold is passed and there becomes a decreasing marginal utility of consumption and an increasing marginal disutility of pollution (Egli). Cleaner technologies are put in place however, these clean technologies are less productive, hence economic growth and likewise environmental degradation is reduced. The change in the use of technologies is the shift in the use of production technologies.

The abatement technology on the other hand, according to Egli, captures the fact that pollution can be alleviated by investing in resources that would help improve environmental quality. Since at the initial stage of economic growth and development, material wealth is on the increase and the environment is neglected, abatement tools become necessary. Environmental degradation becomes an issue to be eliminated. Therefore, economic growth reduces. Egli also state that assuming the abatement technology exhibits increasing returns to scale, the authors demonstrate that an inverted – U shaped pollution – income relationship is the result.

2.4. EMPIRICAL AND METHODOLOGICAL REVIEW

The empirical and methodological framework consists mainly of scholarly works from other authors and the variables which was employed in their study, it also consists of the methods used by the authors to get there results.

Bravo and Marelli (2007) attempted to enquire into the issue of some basic micro – level assumptions at the foundation of the EKC hypothesis to test whether they were empirically sound. Their conclusion was that " the relation between GDP and both environmental attitudes and actions is at best weak: many of the identified indexes or factors show no appreciable relation with GDP and even when this happens, the identified functional forms tend to be inconsistent with the EKC hypothesis." Hence, Bravo and Marelli question the empirical validity of the micro – foundations of the EKC hypothesis.

Orubu et.al (2009) attempt to discover the existence of EKC in Africa for five indicators of environmental quality which include: suspended particulate matter (SPM), organic water pollutants (OWP), access to sanitation (ASN), carbon dioxide (CO_2) and access to safe water (ASW). Their findings revealed that the EKC hypothesis existed for only four out of the five indicators of environmental quality tested. These include: SPM, OWP, CO_2 and ASN. The non – existence of EKC for ASW indicates that a rise in average incomes may not necessarily increase the access to safe drinking water in African countries, thereby raising fundamental questions about the distributional consequences of economic growth. One general observation made about the five indicators of environmental quality tested was that the income turning points are generally low compared to what obtains for the same measures of environmental quality in developed industrial countries.

Omojolaibi (2010) did a study on environmental quality (measured by carbon emission, CO_2) and economic growth (measured by GDP) in some selected West African countries which included: Nigeria, Ghana and Sierra Leone. The study discovered that West Africa's contribution to global carbon emission is low, however there role in carbon abatement is highly important.

Omojolaibi also discovers that the EKC is "definitely not a convincing tool that is able to explain how an economy deals with its environmental quality while growing."

Lieb (2002) also carried out a survey of empirical evidence as well as the possible causes. Lieb discovered the presence of an EKC for flow and local pollutants, but a monotonically rising pollution – income relationship (PIR) for stock and global pollutants. The reason being that for a particular pollutant, an EKC would only exist when policy measures are put in place with respect to the pollutant as for flow and local pollutants.

Bagliani, Bravo and Dalmazzone (2008) carried out a consumption – based study on the EKC while making use of the ecological footprint indicator. The main aim of the study was to deepen the knowledge on the consumption pattern of individuals while making use of the ecological footprint, which is a small indicator of environmental pressure. The outcome of their study did not fall in line with the proposed EKC hypothesis, which is that of an inverted – U shape. According to Bagliani et.al, "the absence of an inversion in trend in ecological footprint when GDP per capita rises appears to indicate that indefinite economic growth within a clean environment cannot be achieved simultaneously by the whole planet, since it can only locally until there are countries whose environment is allowed to deteriorate."

Orubu and Awopegba (2009) made use of certain environmental indicators in there study some of which include: suspended particulate matter (SPM), carbon emissions (CO_2), organic water pollutants (OWP), lack of access to sanitation (ASN) as well as lack of access to safe water (ASW). The study covered the African continent with data sets ranging from 1975 – 2002. The Pearson correlation coefficient was adopted in the study. The Hausman test was also used to choose between the relevant fixed and random effects models. SPM, CO_2, OWP and ASN are found to conform to the inverted – U relationship between income and measures of environmental quality. No significant EKC relationship was established for the ASW.

Sayed and Sek (2013) focused their study on over 40 countries with data set spanning 1961 to 2009. They carried out an empirical study on five common pollutant emissions which are: carbon emissions (CO_2), sulfur dioxide (SO_2), biochemical oxygen demand (BOD), suspended particulate matter (SPM), and greenhouse gas emissions (GHG). The aim of their study was to deduce whether the EKC hypothesis held in developed as well as developing economies of the world. The empirical study of Sayed et al. employs panel model which are the fixed effects models (FE) and the random effects models (RE). The result of their study was deduced to be a case of higher turning points in developed countries than in developing countries. In the developed countries, the CO_2 and the BOD have higher turning points of inverted – U shape while in developing countries; SO_2 has a higher turning point of inverted – U shape.

Also, some EKC studies have focused on deforestation and whether or not the EKC theory would hold in such cases. Bhattarai and Hammig (2001) carried out a cross – country analysis for Latin America, Africa and Asia, looking at institutions and the EKC for deforestation in those regions. The study examined the relationship between the rate of deforestation and income in 66 countries which ranged from Latin America, Asia and Africa for the period of 1972 - 1991. The data set constituted of 20 countries from Latin America, 12 countries from Asia and 31 countries from Africa. The panel data technique was carried out and the method of regression analysis used was the simple pooled regression as well as the fixed effects and random effects models. The fixed effects model was estimated by the weighted least square (GLS). The result from the study was that strengthening sociopolitical institutions would help to reduce deforestation in tropical countries as well as flatten the EKC for deforestation. The results also capture the global environmental protection concept which the EKC theory stands for.

Begun and Eicher (2007) likewise carried out a study in search of sulfur dioxide EKC while using a Bayesian Model Averaging (BMA) approach. The SO_2 data was gathered in up to 44 countries from the period of 1971 to 2006. A weak evidence for the EKC was discovered, hence the EKC was found not to hold in the study.

Similarly, Chen carried out a study on economic growth and the environment in China. The analysis was carried out using five kinds of industrial pollutants (solid wastes, waste water, soot, smoke and SO_2). The study also included the use of 29 municipalities over the period of 1992 and 2005. The study made use of cross – country data and the reduced form model is used to test for the EKC. The concluding results showed that the EKC relationship exists in the eastern region between industrial SO_2 and per capita GDP. In the middle and western region, the EKC also existed between industrial dust and per capita income. The EKC relationship however did not hold for industrial soot and solid waste, an N – shaped curve was generated.

Another EKC study was carried out by Choi, Heshmati and Cho (2010) while examining the relationship between carbon emissions, economic growth and openness. The study incorporated the time – series data from a time period of 1971 – 2006 in China (an emerging economy), Korea (a newly industrialized economy) and Japan (a developed country). The main variables used were: CO_2, GDP and openness. Vector auto regression (VAR) was used to test the short – run relationship between the determinants of environmental variables. The Augmented Dickey – Fuller (ADF) as well as the Johansen Cointegration test were also made use of in the study.

CHAPTER THREE

THEORETICAL FRAMEWORK AND RESEARCH METHODOLOGY

3.1 INTRODUCTION

The purpose of this chapter is to describe the research methodology that was used during this study. The objectives of this study are to evaluate the relationship between environmental quality and economic growth and to test for the existence of the EKC in West African countries. This chapter would outline the means through which these objectives will be achieved.

This is a very pertinent part of the study. It consists of model specification, estimation technique, a priori expectation, definition of variables, presentation of data as well as their sources.

3.2 THEORETICAL FRAMEWORK

The theoretical framework analysis which would be made use of in this study are the scale effect, composition effect and the technology effect.

Scale effect

An increase in output would require increasing input. Thus, this will this will require additional use of natural resources that will be made use of in the production process. However, increases output will invariably imply more wastes and emissions being deposited into the atmosphere. When this occurs, it will increase the level of pollution existent in the environment and ultimately, a rise in environmental quality degradation. In other words, economic growth exhibits a scale effect that has a negative outcome on environmental quality.

Composition effect

The composition effect has a positive impact on the environment. At first when economic growth starts to take place, the impact on the environment is negative. As time goes on however, the structure of the economy begins to change from that of an agrarian society or rural society to that of an industrialized urban society. With the industrialized urban society comes another structural change where the economy moves from energy – based economy to knowledge – based economy and engages mainly in services and clean technologies. This goes to show that a composition of the various structural changes an economy undergoes can eventually add up to have an effect on environmental quality which is a positive one.

Technology/ technique effect

The technology effect is reached when the economy of a nation gets to a point where the dirty and unsafe technologies which were once used will be substituted for cleaner technologies which improve environmental quality. A nation can afford to make use of cleaner technologies when they have sufficient funds to invest in research and development. Hence, the techniques of production changes from energy – based one to that of services and knowledge driven economy.

In summary, the EKC suggests that the scale effect might have a negative impact on the environment, but it is eventually outweighed by the positive impact of the composition and technology effect.

3.3 RESEARCH METHODOLOGY

The study makes use of the panel – data methodology in testing for the EKC hypothesis. This is in order to estimate the relationship between suspended particulate matter, carbon emissions, waste generation and water pollution in West African countries. The panel data is presented in a descriptive, analytical and investigatory manner. The data used were obtained from the World Development Indicators (WDI) of the World Bank as well as the World Governance Indicators (WGI). The data would be from 1980 to 2012.

3.3.1 MODEL SPECIFICATION

The econometric model of the study assumed a functional relationship between indicators of environmental quality and its possible determinants. The basic EKC equation is written as:

$$\ln(ED_{it}) = \alpha_i + \beta_1 \ln Y_{it} + \beta_2 (\ln Y_{it})^2 + \beta_4 X_{it} + \varepsilon_{it}$$

Where X_{it} is a vector of other independent variables

Where $X_t = LIRT_{it}, PODN_{it}, TRAD_{it}, INST_{it}$

ED = indicator of environmental degradation

Y = GDP per capita

X_{it} signifies:

LITR = literacy rate

PODN = population density

TRAD = trade openness and;

INST = institutions

i = country

t = time

α = constant

β_k = coefficient of the independent k variables

ε_t = stochastic variable or error term

The variables Y_t, Y_t^2 and Y_t^3 simply represent the shape of the EKC function. Y_t^2 is the quadratic change while Y_t^3 is the cubic change which occurs in the EKC. Y_t explains the case that initial development in a country increases the level of environmental degradation. Y_t^2 and Y_t^3 signify the presence of the inverted – U shape.

EXPLANATION OF VARIABLES

Literacy rate is included because countries that have a higher number of educated adults or literate adults will have citizens who are more willing to take proper care of the environment and are conscious about the side – effects of pollution.

Population density also plays a significant role in determining the level of environmental degradation. A higher population connotes higher pollution levels because of intense pressures that will be placed on the available natural resources. Less population however signifies lower pollution levels and less pressure on natural resources.

Again is the trade openness variable. Trade openness is included because it is more likely for a country that opens up its borders and allows free trade to suffer from a higher pollution level because of the issue of dumping than a country that strictly guards its borders and regulates dumping by multinational companies.

Institutions play a major role in reducing environmental degradation. Policies set up or put in place by governmental agencies help to curb negative effects of technology on the environment hence these institutions would help in adoption of cleaner technologies.

3.3.2 APRIORI EXPECTATIONS

The a priori expectation provides expected signs and significance of the value of the coefficient of the model parameters to be estimated in light of economic theory and empirical evidence. They include:

i. $\beta_1 = \beta_2 = \beta_3 = 0$. This signifies that there is no relationship between pollution and income. It is a flat form.

ii. $\beta_1 > 0$ and $\beta_2 = \beta_3 = 0$. This implies a linear or monotonically increasing pollution environmental degradation and income.

iii. $\beta_1 < 0$ and $\beta_2 = \beta_3 = 0$. There is a monotonically decreasing relationship between pollution and income.

iv. $\beta_1 > 0$, $\beta_2 < 0$ and $\beta_3 = 0$. This implies there is an inverted – U relationship between pollution and income. This is the EKC relationship.

v. $\beta_1 < 0$, $\beta_2 > 0$ and $\beta_3 = 0$. This is a U – shaped relationship.

vi. $\beta_1 > 0$, $\beta_2 < 0$ and $\beta_3 > 0$. This signifies an N – shaped figure or a cubic polynomial.

vii. $\beta_1 < 0$, $\beta_2 > 0$ and $\beta_3 < 0$. This is the opposite of the N – shaped figure.

3.3.3 TECHNIQUE OF ESTIMATION

The estimation technique which will be used in this study is the fixed effects (FE) and the random effects (RE) models. The Hausman test is also used in order to determine whether the fixed effects or the random effects are more appropriate.

Fixed effects (FE)

The fixed effects model of estimation is used when we want to examine the impact of variables which vary over time. Fixed effects model also explore the relationship between predictor and outcome variables within an entity. The fixed effects model also controls for all time – invariant differences so that the approximated coefficients of the fixed – effects models would not be biased as a result of omitted time – invariant characteristics. Summarily, the main aim of the FE models is in order to examine the causes of changes within an entity. (Torres-Reyna, 2010).

Random effects (RE)

Under the rational effects model, the variations in the entity are assumed to be un – connected to the independent or explanatory variables which are existent in the model. The random effects estimator also provides estimates for time – constant covariates. In the RE model, distributional assumptions are made on the error term and an estimation method is used which crosses out the irrelevant parameters. When a pooled – GLS estimator is made use of, the random effects estimator is derived. (Bruderl, 2005).

Hausman test

The Hausman test is used to decide between the fixed effects model and the random effects model (Ogundipe and Ogundipe 2013). It is used to determine which of the two models is appropriate. The Hausman test evaluates that the error terms are correlated with the regressors.

Justification for the use of fixed effect and random effect models

The fixed and random effects are better than other techniques of estimation as result of the following:

1. The RE model assists in providing estimates for time – constant covariates.
2. The FE model is used to derive unbiased estimates.
3. The FE is a better measure of identifying the true causal effect of an entity.
4. The FE and the RE models help to analyze panel data which constitutes of time – series data and cross – sectional data.

Weaknesses of the fixed and random effects models

1. Under the FE model, the effect of a time – constant covariate cannot be estimated.
2. Also under the FE model, if the assumption of exogeneity is violated, it could lead to the problem of endogeneity which could occur even as a result of issues with the panel data. Endogeneity could occur as a result of: omitted variables, periodic shocks and so on.

3.3.4 SOURCES OF DATA AND MEASUREMENT

This section constitutes of the variables used in this study as well as the sources of data and the measurement used for the variables. The explanatory variables made use of in the study include: literacy rate, population density, trade openness and institutions.

Table 3.1 Variables, Measurement and Source

VARIABLES	MEASUREMENT	DATA SOURCE
GDP per capita	GDP per capita constant (constant 2005 US $)	World Development Indicators (WDI) 2013 of World Bank
Literacy rate	School enrollment, Secondary (% gross)	World Development Indicators (WDI) 2013 of World Bank
Population density	People per sq. km of land area	World Development Indicators (WDI) 2013 of World Bank
Trade openness	(Import + export) / GDP	World Development Indicators (WDI) 2013 of World Bank
Institutions	Control of corruption, regulatory quality, rule of law and voice and accountability	World Governance Indicators (WGI) 2013 of World Bank

CHAPTER FOUR

DATA ANALYSIS AND INTERPRETATION

4.1. INTRODUCTION

The main focus of this chapter is on the presentation, estimation as well as the analysis of data in order to address whether EKC's exist for carbon emissions (CO_2) in West Africa which is a measure of environmental quality. The analysis therefore covers the descriptive as well as the econometric analysis. The model specified in the previous chapter is used in this present chapter in order to determine the pattern and shape of relationships that exist between carbon emissions and per capita income.

The econometric analysis conducted is that of the pooled OLS, fixed effects (FE) and random effects (RE) in order to establish whether the EKC exists in West African countries and to examine the effects of the explanatory variables on the dependent variable. For these analyses, the data is sourced from the World Development Indicators (WDI) as well as the World Governance Indicators (WGI).

4.2. SUMMARY STATISTICS

The summary or descriptive statistics is presented in the table below.

Table 4.1 Summary Statistics

	LCO_2 M	LGDPK	$LGDPK^2$	LLIRT	LPODN	LTRAD	LINST
Observations	496	489	489	310	512	484	528
Mean	-1.517665	6.090589	37.31188	2.861932	3.576578	4.137087	0.7814105
Std. dev.	0.7839504	0.4658822	5.570944	0.6457935	1.083733	0.4083691	0.2342685
Minimum	-3.110637	3.912867	15.31053	0.910007	0.3977325	1.843773	-0.4483463
Maximum	0.5659302	7.292082	53.17446	4.074831	5.194507	5.188061	1.133184
Skewness	- 0.0059954	- 0.5643313	- 0.924658	-0.454498	-1.137672	- 0.6868951	-1.712121
Kurtosis	2.539096	5.650772	4.319949	2.975168	3.65761	5.591052	5.869814

Computed by Researcher using Stata 11.0

1. Mean can be seen as the average value of a set of series which can be derived by summing up the series and dividing by the number of observations. Mean also refers to a measure of central tendency. From the table above the mean of the dependent and independent variables respectively have already been calculated from Stata. LCO_2M (carbon emissions, metric tons per capita) is -1.517665, GDPK (GDP per capita) is 6.090589, $GDPK^2$ (GDP per capita squared) is 37.31188, LIRT (literacy rate) is 2.861932, PODN (population density) is 3.576578, TRAD (trade openness) is 4.137087 and INST (institutions) is 0.7814105.
2. Maximum and minimum are collectively known as extrema and they are the highest and lowest values that a function can accommodate at a point. The maximum and the minimum values respectively are the highest and lowest values of the series in the current sample. From the table above, the maximum of CO_2M (carbon emissions, metric tons per

capita) is 0.5659302 while the minimum is -3.110637, the maximum of GDPK (GDP per capita) is 7.292082 and its minimum is 3.912867, the maximum of $GDPK^2$ (GDP per capita) is 53.17446 and its minimum is 15.31053, the maximum of LIRT (literacy rate) is 4.074831and its minimum is 0.910007, the maximum of PODN (population density) is 5.194507 and its minimum is 0.3977325, the maximum of TRAD (trade openness) is 5.188061 and is minimum is 1.843773, the maximum of INST (institutions) is 1.133184 and its minimum is -0.4483463.

3. Standard deviation simply refers to the measure of dispersion or spread in the means. It is a deviation from the original mean. It is also a measure of how spread out the numbers are. From the table above, the standard deviation of LCO_2M is calculated as: 0.7839504, LGDPK is 0.4658822, $LGDPK^2$ is 5.570944, LLIRT is 0.6457935, LPODN is 1.083733, LTRAD is 0.4083691 and LINST is 0.2342685.
4. Skewness is made use of in distribution analysis as a measure of asymmetry of the distribution and its deviation from its normal distribution. Skewness can be positive, negative or even undefined. From the table drawn above, the skewness of LCO_2M is -0.0059954, LGDPK is -0.5643313, $LGDPK^2$ is -0.924658, LLIRT is -0.454498, LPODN is -1.137672, LTRAD is -0.6868951 and LINST is -1.712121.
5. Kurtosis is used to measure the peakedness of flattening of a probability distribution of a real-valued random variable. Kurtosis illustrates the shape of the probability distribution. From the above, the kurtosis of LCO_2M is 2.539096, LGDPK is 5.650772, $LGDPK^2$ is 4.319949, LLIRT is 2.975168, LPODN is 3.65761, LTRAD is 5.591052 and LINST is 5.869814.

4.3. ECONOMETRIC ANALYSIS

An econometric analysis is carried out in order to address the broad as well as specific objectives listed in the study, which is to examine empirically the existence of EKC in West Africa.

4.3.1. CORRELATION MATRIX

The test for multicollinearity is carried out when we are trying to establish if there is a perfect linear relationship among one or more of our explanatory variables in a regression analysis. The test is therefore carried out to check for the extent of relationship between the explanatory variables. The Variance inflation factor (VIF) test for multicollinearity was carried out on Stata and the results are presented in the table below. The rule of thumb for multicollinearity when making use of the VIF test is that when VIF < 5 or when 1/VIF > 0.5, there is absence of multicollinearity. From the table below, LGDPK and $LGDPK^2$ have their VIF to be greater than 5 and their 1/VIF to be < 0.5. This signifies the presence of multicollinearity. LLIRT, LPODN, LTRAD and LINST however have their VIF to be < 5 and their 1/VIF to be greater than 0.5. This signifies the absence of multicollinearity and we can therefore continue with our analysis.

4.3.2. PANEL DATA ANALYSIS

Under the panel data estimation technique, the fixed effect and random effect models were used and in an attempt to determine which of the tests were suitable for our analysis, series of regressions were carried out.

In carrying out the econometric analysis, three techniques were used to analyze our panel data and they include:

i. Pooled OLS model
ii. The Fixed effects model
iii. The Random effects model

FIXED EFFECTS MODEL

The fixed effects model is used in analyzing the impact of variables which vary over time and it used for all time – invariant differences so that the estimated coefficients of our FE model would not be biased as a result of omitted time – invariant characteristics. The FE model also explores the relationship between the explanatory and dependent variables. When talking about FE also, we are referring to unique traits or characteristics which are found in individual countries. Those characteristics are unique to just that particular country or entity e.g. culture. These individual characteristics may or may not influence the explanatory variables. Therefore when carrying out the FE test we assume that something within the entity may lead to the bias of our explanatory variables therefore we need to control for this.

RANDOM EFFECTS MODEL

Under the RE model, the variation which occurs across entities is assumed to be random and uncorrelated with the independent variables which are used in the model. Random effects are also not unique to a particular country as it can occur in any entity. In RE, it is needed to specify those characteristics that may or may not influence the outcome of your independent variable. Re also allows for the generation of inferences beyond what is given in the model. One advantage of random effects is that it can include time – invariant variables.

In order to determine the efficient and effective model to use in our analysis (the fixed effects or the random effects), the Hausman test is used. Basically the Hausman test helps in deciding whether the FE or the RE is suitable for our regression analysis. The null and alternative hypothesis of the Hausman test is specified as follows:

H_o = var(b) = var(B) = there is a correlated random effect

H_1 = var(b) = var(B) = there is no correlated random effect

The null hypothesis states that there is a correlated random effect which signifies that the random effect estimates are preferred to the fixed effects estimates, while the alternative hypothesis states that there is no correlated random effect which signifies that the fixed effects estimates are preferred to those of the random effects estimates.

The rule of thumb for the Hausman diagnostic test is that if the probability of $chi^2 < 0.05$, then it is significant and the null hypothesis is rejected while the alternative hypothesis accepted, however if the probability of $chi^2 > 0.05$, then it is not significant and the null hypothesis is accepted while the alternative hypothesis is rejected.

4.4. DISCUSSION OF RESULTS

Table 4.2 Pooled OLS, Fixed effects and Random effects result

VARIABLES	POOLED OLS	FIXED EFFECTS	RANDOM EFFECTS
LGDPK	-0.0778963 (0.04)	6.447826 (3.75)*	4.976933 (2.97)
$LGDPK^2$	0.1236685 (0.72)	-0.4639668 (3.27)*	-0.3392238 (2.46)*
LLIRT	0.2402279 (3.36)*	-0.1397521 (1.98)*	-0.1128898 (1.75)
LPODN	0.0128511 (0.38)	-0.171592 (0.16)	0.0048209 (0.06)
LTRAD	0.1925376 (2.13)*	-0.0386977 (0.70)	-0.2873367 (0.52)
LINST	0.1783785 (0.88)	-0.1805117 (1.57)	0.2014438 (1.76)
R-squared	0.5970	0.3768	0.4351
Adjusted R-squared	0.5883		

Prob>chi2 = 0.0043. * depicts significant at 5% level of significance.

Source: computed by the author. Notes: The absolute t-statistics are displayed in brackets below the coefficient estimates.

From the table above, the probability value of chi^2 < than 0.05 which implies that it is significant and has therefore indicated that the results generated from the fixed effects were more efficient than those generated from random effects. The results therefore conclude that the fixed effects method of analysis is suitable for the study and so we reject the null hypothesis and accept the alternative hypothesis.

Following the use of the Hausman test to determine whether the FE or the RE tests was more efficient, the results derived stated that the fixed effects tests were more reliable than the random effects test. However, in deriving a suitable fixed effects model, certain variables were included and dropped along the line in the course of the regression. The explanatory variables that were initially regressed included: GDP per capita (LGDPK), square of GDP per capita ($LGDPK^2$), literacy rate (LLIRT), population density (LPODN), agricultural output (LAGROT), trade openness (LTRAD) and institutions (LINST). However, when the initial fixed effects test of these variables was carried out, the probability of the t-statistics and the t-statistics were not giving reliable answers. Also, the coefficients were not in line with the a priori expectations. In the next FE test, the agricultural output (LAGROT) was dropped from the regression. A priori expectations again were not met. In the next fixed effects test, the trade openness variable (LTRAD) was dropped but we were not satisfied with the derived results. The FE test was run again this time without the agricultural output (LAGROT) and the trade openness (LTRAD) variables, however the results were not meeting the required expectations. The last FE test that was run included the trade openness variable (LTRAD) and excluded the agricultural output variable (LAGROT). The results gave a suitable a priori expectation and this became our FE estimation model for our analysis.

We now begin to discuss our results according to the chosen model which is the fixed effects model according to the Hausman specification.

From the results derived in the above Stata table, we begin to explain our coefficients with respect to our logged dependent and independent variables. Thus, the following results can be interpreted as: a change in GDPK will bring about a more than proportionate increase in carbon emissions in West Africa because GDPK is elastic (more than 1). A change in $GDPK^2$ will bring about a less than proportionate increase in carbon emissions in West Africa because of the fact that $GDPK^2$ is inelastic (less than 1). Also, a unit change in literacy rate will bring about less than proportionate increase in carbon emissions in West Africa because literacy rate is inelastic (less than 1). A unit change in population density will bring about a less than proportionate increase in carbon emissions in West Africa because population density is inelastic and less than one. Also, a unit change in population density will bring about a less than proportionate increase in carbon emissions in West Africa because there elasticities are less than one and inelastic. The same goes for trade openness and institutions, where a unit change in both will bring about a less than proportionate increase in carbon emissions in West Africa because there elasticities are also less than one.

The results show that a unit change in $LGDPK^2$ will bring about a 46.3% change in carbon emissions and it is significant at 1 percent. A unit change in LLIRT will bring about a 13.9% change in carbon emissions and it is significant at 5 percent. A unit change in LPODN will bring about a 17.1% change in carbon emissions. Similarly a unit change in LTRAD will bring about a 36.8% increase in carbon emissions. Lastly, a unit change in institutions, INST (which constitutes of control of corruption, regulatory quality, rule of law and voice and accountability) will bring about an 18.05% change in carbon emissions, significant at 10 percent.

The rule of thumb for the t-statistics states for the value of t-statistics to be significant, the absolute value of t-statistics must be greater than two. LGDPK and $LGDPK^2$ have their t-statistics to both be statistically significant at one percent level of significance. Also, the t-statistic value of LLIRT is significant at five percent level of significance. The variables LPODN and LTRAD do not have their absolute value of the t-statistic to be significant and the probability value of t-statistic is also not significant. LINST on the other hand, has the absolute value of t-statistics to be significant at 10 percent level of significance.

4.5 FINDINGS AND ECONOMETRIC INTERPRETATION OF RESULTS

The result from our analysis has a number of economic implications in the West African region. Based on our fixed effects model, the negative sign which was indicated by our $LGDPK^2$ variable depicts a sign of EKC in West Africa. This goes in line with certain works which have previously been conducted in the past as regards the EKC. Orubu et.al (2009) found the existence of EKC for CO^2 in African countries. However, Omojolaibi (2010) carried out a research to detect for the presence of EKC in the following West African countries: Nigeria, Ghana and Sierra Leone and concluded based on the results derived from the fixed effects table that the EKC does not apply to West Africa and is therefore not a good enough judge of the CO_2 relationship in West Africa. The negative sign implies that as GDP per capita increases, environmental degradation is also increasing, but a certain threshold is reached when GDP per capita reaches a point and environmental degradation begins to fall. The result therefore showed that there is a negative but significant relationship between $GDPK^2$ and carbon emissions. This therefore goes in line with the a priori expectation of the EKC that as per capita income increases, pollution level also increases. The impact which the squared of GDP per capita has on carbon emissions in West Africa is therefore significant.

The independent variable LLIRT has a negative but insignificant relationship with carbon emissions in West Africa. These results showed that as literacy rate increases, there is an increase in carbon emissions in West Africa. This does not go in line with the a priori expectation that as people become educated, they become more aware of their environment thereby willing to take better care of their environment. It is therefore expected that as literacy rate rises, pollution levels decline. This is however not the case in our analysis and this could be as a result of the fact that education in West Africa cannot be compared to other regions of the world where the government spend a huge sum of money on the education of citizens. In Nigeria and other West African countries inclusive, education is not given the required attention which it should be given especially as tertiary institutions go on strike day in day out and students become adversely affected without receiving the qualitative education which they deserve. Currently in Nigeria, government spends just 12 percent of the national budget on education, however just recently the United Nations Educational, Scientific and Cultural Organization (UNESCO) instructed the Nigerian government to increase their budget on education to 26 percent. With the result derived from our analysis, it means that the impact of literacy rate on carbon emissions in West Africa is not significant.

The variable LPODN has a negative but insignificant relationship with carbon emissions in West Africa. The result explains that as population density rises, carbon emissions in West Africa falls, but this is also not in line with a priori expectations. It is expected that as the number of people in the West African region increase, there becomes more pressure on the existing natural resources which leads to an increase in pollution. The reason for this sort of result could be that even though the population in West Africa is rising, the people do not carry out much technologically driven production activities, but rather they engage in agricultural activities which does not affect pollution levels as much as technology. This result therefore means that the impact of population on carbon emissions in West Africa is not significant.

Similarly the independent variable LTRAD has a negative but significant relationship with carbon emission in West Africa. The result explains that as trade openness rises, carbon emissions in West Africa also rise. Trade openness is the extent to which a country's borders are open to the foreign market. A priori expectations state that when a country has a wide range of countries it is dealing with on the international trade spectrum, environmental degradation tends to rise especially when dumping activities are not properly taken care of. Our analysis is therefore significant because the result goes in line with what is expected. This means that since most countries in the West African region do not control their borders properly and regulate dumping activities, pollution has risen significantly.

The last independent variable which is LINST possesses a positive but significant relationship with carbon emissions in West Africa. This is because of the fact that our results depict that as the roles of institutions improve the level of environmental quality increases. This goes in line with a priori expectations that as institutional quality increases, there will be reduced levels of pollution activities in West Africa. Therefore, institutions in West Africa which include: control of corruption, rule of law, regulatory quality and voice and accountability play major roles in reducing the level of carbon emissions and in the long run environmental quality reduction in West Africa.

CONCLUSION

This chapter contains a summary of the result analysis and the analysis shows that for some of the independent variables, they met the required a priori expectations while some others did not. Population density and literacy rates did not meet a priori expectations because of the fact that in West Africa, it is a known fact that some of the data derived on these variables are not of a standard quality and can sometimes go against what is expected in reality. Some of the data figures are incorrect and this affects our analysis in the long run.

CHAPTER FIVE

SUMMARY, RECOMMENDATION AND CONCLUSION

5.1 Summary

The research work set out to carry out an empirical examination of Environmental Kuznets Curve (EKC) in West Africa. In general, the study set out to establish if EKC existed in West African countries for an indicator of environmental quality which is carbon emissions (CO_2). The study also sought to examine the effects of certain macro-economic variables on the level of environmental quality in West Africa.

Making use of the scale, composition and technology effects as its bases, an empirical study was carried out via the panel data analysis between 1980 and 2012 and the analysis was carried out using the Fixed effects (FE), Random effects (RE) and the pooled OLS estimation in order to achieve the stated objectives. The data used for the analysis are: carbon emissions (CO_2 emissions), GDP per capita (GDPK), secondary school enrollment (LIRT) as proxy for literacy rate, population density (PODN), trade openness (TRAD) and institutions (INST) which constitute of: rule of law, voice and accountability, regulatory control and control of corruption.

Our results showed that EKC does exist in West Africa because of the negative sign which the squared of GDP per capita carries. The increase in GDP per capita squared signifies that environmental degradation is also increasing; however the negative sign in GDP per capita squared implies that a turning point or a threshold has been reached where pollution levels begin to decline with the corresponding increase in per capita income. Our results also confirmed that CO_2 has a negative relationship with LIRT and TRAD in which carbon emissions rise as literacy rate and trade openness rises. Also, our results confirmed that CO_2 has a positive relationship with PODN and INST in which CO_2 emissions fall as population density and quality of institutions increase.

However, the positive relationship between CO_2 and PODN contradicts a priori expectation while the negative relationship between CO_2 and LIRT also contradicts a priori expectation.

5.2 Recommendations

The major recommendation with regards to the results found in the previous chapter which states that literacy rates bring about an increase in environmental degradation while population density brings about a decrease in environmental degradation includes:

1. **Improvements in the quality of education in the West African region**

The governments of the various West African regions should ensure adequate attention is given to education in their respective countries. This is because according to the a priori expectation, education is meant to reduce the level of environmental degradation due to the fact that as more people become enlightened, they become aware of their environment and seek for ways to make their environment cleaner. However, in most West African regions, education does not seem to make much of an impact. Therefore, efforts should be made by the governments to enhance the quality of education in West Africa so that resulting positive impacts can be witnessed on the environment.

2. **Inaccuracy of population census in West African countries**

Most West African countries have inaccurate population data which cause the results gotten from the regression analysis to not conform to what is expected in reality. Population censuses are conducted in these countries, but more often than not there are cases of double counting, inability of census officials to get to certain destinations due to transportation challenges or lack of security and so on. Also population census figures in West African countries are doctored in order to appropriate funds to particular local government areas or states in the country by corrupt public officials.

5.3 Conclusion

From our analysis, it can be seen that the EKC exists in West Africa and therefore pollution levels are evident. However, since there is the presence of an EKC the negative turning point which is witnessed would bring about a decline in environmental pollution as per capita income begins to rise and better care is given to the environment. This study therefore shows that despite the level of environmental degradation in West Africa, there can still be a turnaround.

5.4 Limitations of the study

There were a number of limitations experienced in the course of the study but to mention a few. The scarcity of data for macro-economic variables which is a characteristic of most research work was a major limitation. Majority of the data gathered for each of the sixteen West African countries were incomplete with some countries having very little data with which to work with. It is also common knowledge that secondary data are filled with estimation errors and the extent of accuracy of our work is limited to the accuracy of data at our disposal.

Another limitation of this study was that of time constraint. The time period used in carrying out this study had to be shared with the normal course work, chapel services as well as the leadership programme which was made compulsory on a daily basis for students to be in attendance. Hence, proper time allocation had to be carried out in order to achieve maximum output.

5.5. SUGGESTIONS FOR FURTHER STUDIES

Further studies can therefore focus on the use of additional independent variables in their work such as foreign direct investment, or the use of other indicators of environmental quality which include: suspended particulate matter, nitrogen oxide and so on. Also, the Environmental Kuznets Curve hypothesis could be narrowed down to the Nigerian context with the aim of discovering whether there is the presence of EKC in Nigeria.

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APPENDIX

POOLED OLS RESULT

Source	SS	df	MS
Model	131.813521	621.9689202	
Residual	88.9768473	279.318913431	
Total	220.790368	285.774703047	

Number of obs = 286
F(6, 279)=68.89
Prob > F = 0.0000
R-squared = 0.5970
Adj R-squared = 0.5883
Root MSE =.56472

lco2m	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lgdpk	-.0778963	2.153919	-0.04	0.971	-4.317892	4.162099
lgdpk2	.1236685	.1724287	0.72	0.474	-.215758	.463095
llirt	.2402279	.071431	3.36	0.001	.0996156	.3808401
lpodn	.0128511	.0334325	0.38	0.701	-.052960	.078663
ltrad	.1925376	.0902732	2.13	0.034	.0148345	.3702408
linst	.1783785	.2016621	0.88	0.377	-.218594	.5753509
_cons	-7.376299	6.555346	-1.13	0.261	-20.28052	5.52792

MULTICOLLINEARITY RESULT

Variable	VIF	1/VIF
lgdpk	639.22	0.001564
lgdpk2	629.25	0.001589
llirt	1.89	0.528909
lpodn	1.40	0.713641
ltrad	1.33	0.751790
linst	1.31	0.762654

Mean VIF | 212.40

FIXED EFFECTS RESULT WITH THE INCLUSION OF LAGROT

```
Fixed-effects (within) regression               Number of obs = 241
Group variable: id                              Number of groups = 14

R-sq:  within = 0.2620                          Obs per group: min = 3
       between = 0.1839                         avg = 17.2
       overall = 0.2457                         max = 25

                                                F(7,220) = 11.15
corr(u_i, Xb)  = 0.0442                         Prob > F = 0.0000

--------------------------------------------------------------------------
       lco2m |    Coef.   Std. Err.      t    P>|t|   [95% Conf. Interval]
-------------+------------------------------------------------------------
       lgdpk |  2.201746   2.229408     0.99   0.324   -2.191984  6.595476
      lgdpk2 | -.0941785   .1889635    -0.50   0.619   -.4665889  .2782319
       llirt | -.2141918   .0815337    -2.63   0.009   -.3748788  .0535047
       lpodn | .2258491    .1172418     1.93   0.055   -.0052117  .4569098
      lagrot | .4303045    .126988      3.39   0.001   .1800359   .6805732
       ltrad | .0277287    .0599967     0.46   0.644   -.0905131  .1459704
       linst | .2497675    .1331216     1.88   0.062   -.0125892  .5121243
       _cons | -13.48787   6.524613    -2.07   0.040   -26.34661 -.6291247
-------------+------------------------------------------------------------
     sigma_u | .67879821
     sigma_e | .2504789
         rho | .88015497   (fraction of variance due to u_i)
--------------------------------------------------------------------------
F test that all u_i=0:     F(13, 220) =    63.44          Prob >F = 0.0000
```

FIXED EFFECTS RESULT WITHOUT THE INCLUSION OF LAGROT

```
Fixed-effects (within) regression              Number of obs = 286
Group variable: id                             Number of groups = 15

R-sq:  within = 0.2311                         Obs per group: min = 3
       between= 0.1691                         avg = 19.1
       overall =0.3768                        max = 28

                                               F(6,265 =13.27
corr(u_i, Xb)  = 0.3814                        Prob > F=0.0000

------------------------------------------------------------------------------
       lco2m |    Coef.   Std. Err.      t    P>|t|   [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lgdpk |  6.447826    1.7203     3.75   0.000   3.06063     9.835023
      lgdpk2 | -.4639668   .1417261   -3.27   0.001   -.7430192  -1849144
       llirt | -.1397521   .0705439   -1.98   0.049   -.27865    -.0008542
       lpodn |  .0171592   .1066655    0.16   0.872   -.1928606  .2271789
       ltrad | -.0386977   .0552577   -0.70   0.484   -.147497   .0701024
       linst |  .1805117   .1146869    1.57   0.117   -.0453019  .4063252
       _cons | -23.22528   5.196981   -4.47   0.000   -33.4579   -12.99265
-------------+----------------------------------------------------------------
     sigma_u | .71073987
     sigma_e | .25281696
         rho | .8876822   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(14, 265) =    80.51          Prob > F = 0.0000
```

FIXED EFFECTS RESULT WITHOUT THE INCLUSION OF LTRAD

```
Fixed-effects (within) regression               Number of obs =   243
Group variable: id                              Number of groups = 14

R-sq:  within  = 0.2604                         Obs per group: min = 3
       between = 0.1911                         avg = 17.4
       overall = 0.2513                         max = 25

                                                F(6,223) = 13.08
corr(u_i, Xb)  = 0.0541                         Prob > F = 0.0000

------------------------------------------------------------------------------
       lco2m |    Coef.   Std. Err.    t     P>|t| [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lgdpk |  2.179728   2.219388     0.98   0.327  -2.193928   6.553385
      lgdpk2 |  -.0915903  .1878882    -0.49   0.626  -.4618538   .2786732
       llirt |  -.2014383  .0742607    -2.71   0.007  -.3477809  -.0550958
       lpodn |  .2199208   .1132822     1.94   0.053  -.0033198   .4431615
      lagrot |  .4224142   .1253995     3.37   0.001   .1752946   .6695337
       linst |  .234627    .131372      1.79   0.075  -.0242625   .4935164
       _cons |  -13.31479  6.491638    -2.05   0.041  -26.10759  -.5219801
-------------+----------------------------------------------------------------
     sigma_u | .67477842
     sigma_e | .24944001
         rho | .87977824   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(13, 223) = 66.14         Prob > F =0.0000
```

FIXED EFFECTS RESULT WITHOUT THE INCLUSION OF LAGROT AND LTRAD

```
Fixed-effects (within) regression               Number of obs = 288
Group variable: id                              Number of groups = 15

R-sq:  within = 0.2300                          Obs per group: min = 3
       Between= 0.1830                          avg = 19.2
       overall= 0.3790                          max = 28

                                                F(5,268)=16.01
corr(u_i, Xb)  = 0.3928                         Prob > F=0.0000

--------------------------------------------------------------------------
       lco2m |     Coef.   Std. Err.     t     P>|t|  [95% Conf. Interval]
-------------+------------------------------------------------------------
       lgdpk |  6.316928   1.708131    3.70   0.000   2.953865    9.679991
      lgdpk2 | -.4570745   .1410144   -3.24   0.001   -.7347113  -.1794376
       llirt | -.1105528   .0642652   -1.72   0.087   -.2370817   .0159761
       lpodn | -.0167371   .1004394   -0.17   0.868   -.2144878   .1810136
       linst |  .1786795   .1135434    1.57   0.117   -.044871    .40223
       _cons | -22.81014   5.161168   -4.42   0.000   -32.97173  -12.64855
-------------+------------------------------------------------------------
     Sigma_u | .70575097
     sigma_e | .25190356
         rho | .8869975   (fraction of variance due to u_i)
--------------------------------------------------------------------------
F test that all u_i=0:     F(14, 268) =    82.80        Prob > F = 0.0000
```

FINAL FIXED EFFECTS RESULT WITHOUT THE INCLUSION OF LAGROT

```
Fixed-effects (within) regression               Number of obs = 286
Group variable: id                              Number of groups = 15

R-sq:  within = 0.2311                          Obs per group: min =3
       between= 0.1691                          avg =19.1
       overall= 0.3768                          max = 28

                                                F(6,265)= 13.27
corr(u_i, Xb)  = 0.3814                         Prob > F=0.0000

------------------------------------------------------------------------------
       lco2m |      Coef.   Std. Err.     t    P>|t|  [95% Conf. Interval]
-------------+----------------------------------------------------------------
       lgdpk |   6.447826    1.7203      3.75   0.000  3.06063     9.835023
      lgdpk2 |  -.4639668   .1417261    -3.27   0.001  -.7430192 -.1849144
       llirt |  -.1397521   .0705439    -1.98   0.049  -.27865    -.0008542
       lpodn |   .0171592   .1066655     0.16   0.872  -.1928606  .2271789
       ltrad |  -.0386977   .0552577    -0.70   0.484  -.1474978  .0701024
       linst |   .1805117   .1146869     1.57   0.117  -.0453019  .4063252
       _cons |  -23.22528   5.196981    -4.47   0.000  -33.4579   -12.99265
-------------+----------------------------------------------------------------
     sigma_u | .71073987
     sigma_e | .25281696
         rho | .8876822   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(14, 265) =    80.51        Prob > F = 0.0000
```

RANDOM EFFECTS REGRESSION RESULT

```
Random-effects GLS regression                   Number of obs = 286
Group variable: id                              Number of groups = 15

R-sq:  within =  0.2276                         Obs per group: min = 3
       Between = 0.2482                         avg = 19.1
       Overall = 0.4351                         max = 28

Random effects u_i ~ Gaussian                   Wald chi2(6)= 83.31
corr(u_i, X)       = 0 (assumed)                Prob > chi2 = 0.0000
```

lco2m	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lgdpk	4.976933	1.675376	2.97	0.003	1.693255	8.26061
lgdpk2	-.3392238	.137743	-2.46	0.014	-.6091951	-.692525
llirt	-.1128898	.0646834	-1.75	0.081	-.239667	.0138874
lpodn	.0048209	.0848925	0.06	0.955	-.1615653	.1712071
ltrad	-.0287367	.0548622	-0.52	0.600	-.1362647	.0787912
linst	.2014438	.1145526	1.76	0.079	-.0230751	.4259626
_cons	-18.92276	5.051169	-3.75	0.000	-28.82287	-9.022648
sigma_u	.48697289					
sigma_e	.25281696					
rho	.78769473	(fraction of variance due to u_i)				

HAUSMAN REGRESSION RESULT

```
                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |       fe           re         Difference          S.E.
-------------+----------------------------------------------------------------
       lgdpk |    6.447826     4.976933        1.470894        .3905734
      lgdpk2 |   -.4639668    -.3392238       -.1247431        .0333637
       llirt |   -.1397521    -.1128898       -.0268623        .0281514
       lpodn |    .0171592     .0048209        .0123383        .0645817
       ltrad |   -.0386977    -.0287367        -.009961        .0065997
       linst |    .1805117     .2014438       -.0209321          .00555
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from
xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from
xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =       18.92
                Prob>chi2 =      0.0043
                (V_b-V_B is not positive definite)
```

SUMMARY STATISTICS RESULT

```
                             lco2m
-------------------------------------------------------------
      Percentiles      Smallest
 1%     -3.07663      -3.110637
 5%    -2.924877       -3.09746
10%    -2.684855      -3.096317       Obs                 496
25%    -2.032467      -3.089404       Sum of Wgt.         496

50%    -1.503097                      Mean          -1.517665
                        Largest       Std. Dev.      .7839504
75%    -.9209013       .3205568
90%    -.5517157       .3693834       Variance       .6145782
95%    -.2876143       .5221177       Skewness      -.0059954
99%     .3187204       .5659302       Kurtosis       2.539096

                             lgdpk
-------------------------------------------------------------
      Percentiles      Smallest
 1%      4.62277       3.912867
 5%      5.53321        3.97215
10%     5.594148        3.98612       Obs                 489
25%     5.801241       4.237898       Sum of Wgt.         489

50%      6.07206                      Mean           6.090589
                        Largest       Std. Dev.      .4658822
75%     6.360565       7.161562
90%     6.679559       7.242851       Variance       .2170463
95%      6.87431       7.283319       Skewness      -.5643313
99%     7.099187       7.292082       Kurtosis       5.650772

                             lgdpk2
-------------------------------------------------------------
      Percentiles      Smallest
 1%        21.37       15.31053
 5%     30.61642       15.77797
10%     31.29449       15.88915       Obs                 489
25%      33.6544       17.95978       Sum of Wgt.         489

50%     36.86991                      Mean           37.31188
                        Largest       Std. Dev.      5.570944
75%     40.45678       51.28797
90%      44.6165       52.45889       Variance       31.03541
```

95%	47.25613	53.04674	Skewness	-.0924658
99%	50.39845	53.17446	Kurtosis	4.319949

llirt

	Percentiles	Smallest		
1%	1.095718	.910007		
5%	1.711592	.9721454		
10%	1.932631	1.08231	Obs	310
25%	2.510507	1.095718	Sum of Wgt.	310
50%	2.892018		Mean	2.861932
		Largest	Std. Dev.	.6457935
75%	3.298907	4.057467		
90%	3.670826	4.063676	Variance	.4170492
95%	3.810141	4.065423	Skewness	-.454498
99%	4.057467	4.074831	Kurtosis	2.975168

lpodn

	Percentiles	Smallest		
1%	.539101	.3977325		
5%	1.115946	.4263445		
10%	1.843534	.454917	Obs	512
25%	3.255047	.4833235	Sum of Wgt.	512
50%	3.856826		Mean	3.576578
		Largest	Std. Dev.	1.083733
75%	4.342671	5.139345		
90%	4.692108	5.144229	Variance	1.174477
95%	4.829484	5.166811	Skewness	-1.137672
99%	5.112122	5.194507	Kurtosis	3.65761

ltrad

	Percentiles	Smallest		
1%	2.934635	1.843773		
5%	3.52035	2.310457		
10%	3.666959	2.446244	Obs	484
25%	3.867886	2.869098	Sum of Wgt.	484
50%	4.155625		Mean	4.137087
		Largest	Std. Dev.	.4083691
75%	4.414129	4.967141		
90%	4.647692	5.035416	Variance	.1667653
95%	4.76913	5.156419	Skewness	-.6868951
99%	4.946609	5.188061	Kurtosis	5.591052

linst

	Percentiles	Smallest		
1%	-.0355424	-.4483463		
5%	.2909738	-.2796814		
10%	.4040124	-.1114181	Obs	528

25%	.6981978	-.0400463	Sum of Wgt.	528
50%	.9162908		Mean	.7814105
		Largest	Std. Dev.	.2342685
75%	.9162908	1.111327		
90%	.9162908	1.111374	Variance	.0548817
95%	.9162908	1.121559	Skewness	-1.712121
99%	1.097327	1.133184	Kurtosis	5.869814