KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF ART AND SOCIAL SCIENCES

DEPARTMENT OF ECONOMICS

SECTORAL PERFORMANCE AND CARBON DIOXIDE EMISSIONS IN GHANA

BY

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DECLARATION

I hereby declare that this submission is my own work towards the MSc. and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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ABSTRACT

This study investigated the effect of sectoral performance on carbon dioxide (CO_2) emissions in Ghana. It employed the use of annual time series data sourced from the World Bank's World Development Indicators from 1974 to 2011. The ADF test proved all the variables to be stationary after first differencing except forest area (used as a proxy for climate change in the study) which assumes stationarity at the log level. There is an existence of co integration among the series. It found a statistically significant negative relationship between the service sector performance and CO_2 emissions. It also found the industrial and agricultural sectors performance to have a positive impact on CO_2 emissions in the long-run but negative in the short-run.

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DEDICATION

To my loving and caring late mother, Talha Inusah (MmaKande) for her unflinching support, care and sacrifices throughout my educational life

TABLE OF CONTENTS

CONTENT
PAGE

LIST OF TABLES

LIST OF FIGURES

FIGURE **PAGE**

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Climate change and global warming have been major concerns to environmentalists and governments of nations lately as a result of their consequences on human life and the environment. The emission of Carbon dioxide (CO_2) is considered the most influential source of global warming (Narayan and Narayan, 2010). It accounts for about 72% of emitted greenhouse gases (Sanglimsuwan, 2011). With increase in activities (such as human activities and changes in land use) directly related to economic growth and development, (CO_2) emissions have risen astronomically in the past century (Boopen and Vinesh, 2010). Carbon dioxide (CO_2) emission has been increasing as a result of the growing usage of fossil fuels for the production of commodities (Sharma, 2011). Changes in income and economic expansion which may be the easiest measure of human advancement may harm the environment if growth is unchecked (Vutha and Jalilian, 2008).

A significant amount of the world's environmental damage is as a result of growing scale of global economic activities in which international trade forms a considerable portion (UN, 2000). Trade liberalization is likely to increase trade volumes, expand economic activities and affect environmental quality (Vutha and Jalilian, 2008). Some empirical works suggest that trade openness has resulted in the acquisition of lower standards of the environment (Nadal and Wise 2004; Watkins and Fowler 2002). Trade provides the platform for consumers to shift the pollution associated with their consumption to other countries (Yunfeng and Laike, 2010). All other things being equal, trade leads to environmental degradation since it increases the size of the economy and this increases pollution (Dinda, 2004).

According to Adom et al., (2012), Africa has been recognized as an attractive place for the rest of the world. This is because the continent is seen to be full of unexploited opportunities in trade and also yearns to grow. They add that as African countries seek to grow, caution must be adhered to on the probable effect this growth will have on the environment, climate and human adaptation.

The most abundant GHG produced and emitted in Ghana is CO_2 (EPA, 2011). From 1989 to 2007, the emissions of CO_2 measured in kilo tonnes generally showed an upward movement with the exception of years 2000 and 2005. With 3344kt emission in 1989, CO_2 emissions increased till 1999 where it dropped from 6549kt to 6288kt in 2000, after which it increased till 2004 (to 7275kt) and dropped to 6956kt in 2005. It increased to 9578kt in the year 2007 (WDI, 2012). The emission of CO_2 in Ghana is about 0.05% of the total global emissions and it places 108th in the global ranking. It represents total emissions per capita of nearly one metric tonnes of carbon dioxide emission (1MtCO2e) per person as at 2006 (EPA, 2011). The Energy sector contributes the largest to emissions in the country accounting for about 41% of the nation's emissions between the years 1990 and 2006. This is followed by the agricultural sector contributing about 38% of the emissions (EPA, 2011).

According to the nation's baseline emission estimate of the vision 2020, CO_2 emissions for the baseline will rise from 7,278Gg in 1994 to 118,405Gg in 2020. (EPA,2000). According to the development options of the vision, a significant increase in human, financial, material and natural resources will be dedicated to improved production in all the productive sectors, in technological development, in the expansion of services and the energy sector. In the deficiency of deterrent actions, the probable ecological outcome of the anticipated boost in economic escalation will take the form of industrial and energy associated production, deforestation, land degradation and over use of water. An imbalance between the environment and growth is practically unavoidable. This implies how prepared the society is to sacrifice its environmental quality to achieve its growth objectives, and vice versa.

1.2 Problem Statement

Most global economies are striving to attain higher economic growth rates in order to better the welfare of citizens. However, striving for elevated economic expansion result to a rise in CO_2 emissions which has serious environmental hazards such as depletion of the ozone layer, spread of diseases, rise in the sea level, droughts, floods and more frequent and stronger storms which are detrimental to the welfare of the citizens. Due to this, various studies such as Narayan and Narayan (2010) ,Akpan and Akpan (2012), Jayanthakumaran et al. (2012), Wang (2012), etc. have been conducted on the impact of economic growth on CO_2 emission. Several other works in Ghana have also investigated economic growth and CO_2 emission.

However, none of the above studies did focus on how the agric, industry and service sector affect CO_2 emissions in Ghana. This is very important because it will help us know which sector(s) must be given the needed attention in the quest to combat CO_2 emissions in Ghana.

1.3 Objective of the study

The objectives of the study include;

i. To investigate the impact of sectoral performance on carbon dioxide emissions in Ghana.

ii. To investigate the impact of carbon dioxide emissions on climate change in Ghana.

1.4 Hypothesis of the Study

The study postulates that;

The agricultural sector has no significant impact on CO_2emissions.

The service sector has no significant impact on CO_2emissions.

The industrial sector has no significant impact on CO_2emissions.

Carbon dioxide has no significant impact on climate change.

1.5 Justification of the Study

The common denominator of most global economies is the quest to achieving economic growth under environmental friendly conditions. Increasing economic growth associated with agriculture, extraction of minerals, drilling of oil, transportation and increased usage of energy put pressure on the environment in the form of pollution and increases in the emission of CO_2.The emission of GHGs are directly related to global warming and this has adverse effect on the environment. With increasing growth in the various sectors of the economy, Ghana is more likely to emit $CO_2$and face harsher consequences of global warming. The various sectors of the economy are of varying intensities in terms of CO_2emissions.

This study therefore seeks to investigate and establish the impact of performance in the agricultural, service and industrial sectors of the economy on CO_2 emission. The study is expected to bring to light which among the three sectors under study contributes much toCO_2 emission in Ghana and hence, signal policy makers as to which sector(s) to be given the requisite attention to combat CO_2emissions in the country. To the best of the writer's awareness, there is little or no evidence of an empirical work showing the connection between CO_2 emissions and sectoral

performance in Ghana. This paper will therefore act as part of a pioneering work for further studies.

1.6 Scope of the Study

The study aimed to find the impact of sectoral performance on CO_2emissions in Ghana. It includes theoretical and empirical discussions on pollution (CO_2) emissions and sectoral performance. The study covers the period 1974 to 2011. The period is chosen due to its relevant and phenomenal coverage of economic programs such as the Economic Recovery Program (ERP), Structural Adjustment Programme (SAP), economic and trade liberalizations. It is also chosen as a result of the availability of data of the choice variables.

1.7 Organization of the study

The study is organized in five chapters. Introduction to the study is the first chapter and it includes; background to the study, problem statement, hypotheses, objectives, justification, scope of the study and world emissions of CO_2. The second chapter reviews literature on pollution (CO_2emissions) and sectoral performance. The third and fourth chapters have methodology for the study and analysis of data respectively. The final chapter contains the summary of findings, conclusion, policy recommendations, practical limitations and suggestions for future research.

CHAPTER TWO

LITERITURE REVIEW

2.1 INTRODUCTION

The main focus of this section of the study is the review of literature on CO_2 emissions and sectoral performance. The chapter is further categorized into four sub sections. Section one reviews the hypothetical literature onCO_2emissions and sectoral growth. Section two reviews experimental works related to the topic and section three deals with $CO_2$and climate change and emissions of CO_2 in the world. Lastly, section four deals with the overview of the Ghanaian economy, emissions of CO_2in Ghana and climate change situation in the country.

2.2 Theoretical Review

This section reviews existing theories (literature) and theoretical works related to the topic.

2.2.1 The Environmental Kuznets Curve (EKC)

The Environmental Kuznets' Curve (EKC) undoubtedly has become the fundamental economic theory underlying the correlation involving economic growth and environmental (pollution) degradation. The EKC hypothesis outlines the relationship between environmental pollution and economic growth. It demonstrates an inverted-U shape curve (Kijima et al. 2010).

The EKC has its root from the Kuznets Curve as postulated by Simon Kuznets (1955). In his work by the title "Economic Growth and Income Inequality", he suggested that growth and income inequality have a u-shaped relationship. This means that as income per capita increases, income inequality also increases, reaches a peak (maximum point) and then starts to fall. Thus at the initial stages of growth, income inequality increases but as higher growth is attained, equality is also attained (Yandle et al., 2002).

The EKC was commenced by Grossman and Krueger (1991) in a work to examine the environmental impact of the North American Free Trade Agreement. Their work showed that as income per capita increase, environmental polution (emissions) also increase but reaches a point and then starts to fall. This means that, as the economy grows emissions increase but as it further grows, environmental quality starts to improve.

They cited three channels with which this nexus between growth and the environment is portrayed. Firstly; in the initial phase of growth coupled with increased need for natural resources and waste generation, environmental degradation rises. They call this process the scale effect. Secondly; the growth might cause changes in the economic structure and move countries toward less polluting activities. This process is also known as the composition effect. Lastly; with increasing growth of the economy and higher incomes attained, countries will face technological substitution by moving toward less polluting processes. This is known as the technical effect. The scale effect represents the rising portion of the curve where environmental degradation increases with growth and the composition and technical effects represent the turning and decreasing portion of the curve. As income increases the living standards of people improve and tend to care more for the quality of their environment and call for better regulations of the environment. This tends to reduce the rate at which the environment is being degraded (Dinda, 2004). Poor people have lesser demand for clean environment.

This suggests that as an economy starts to develop, coupled with increased trade and industrialization, environmental quality is negatively affected but as it continues to develop, improvement in environmental quality is attained. This gives an upturned Ushaped nature or nexus between income per capita (economic growth) and environmental degradation. The inverted U-shaped nexus between income per capita and environmental detorioration is depicted in Figure 2.1.

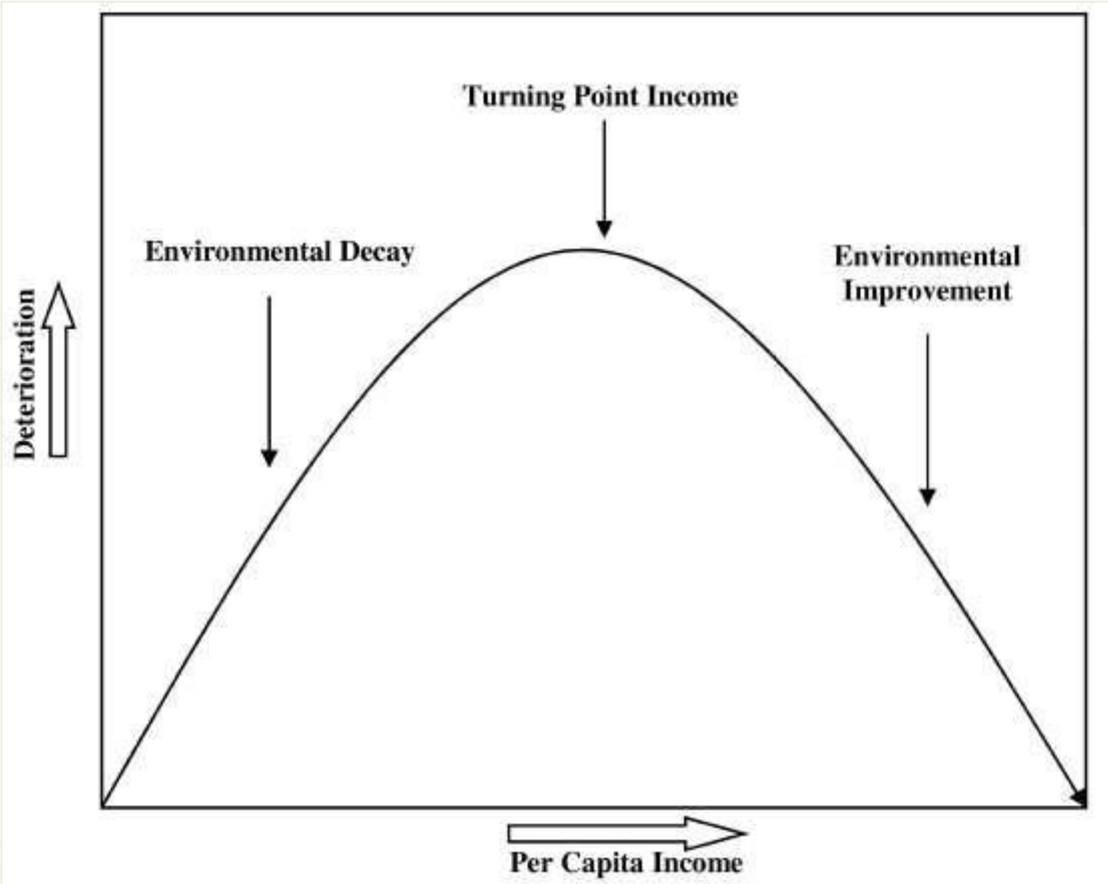

Figure 2.1 The Environmental Kuznets Curve

As per capita income increases degradation of the environment increases, reaches a turning point and then starts to improve.

The issue of income level at which the turning point is attained has become questionable among economists and researchers. Thus, at what stage of development or level of per capita income does the environment start to improve?

Grossman and Krueger (1995) suggest a per capita income of $8000. Holtz-Eakin and Selden (1995) deduce a turning point of $35,418 whilst Neumayer (2004) propose a range between $55,000 and $90,000. Cole (2004) got a maximum point of $62,700 when he used a log-linear model and $25,100 with a levels model for the USA. The EKC portrays a long-run phenomenon (Dinda, 2004).

In recent periods a considerable number of researchers have been concerned about and written largely on the EKC to analyze the correlationthat exist between pollution (environmental degradation) and economic growth and also the validity of the assertion of the EKC. Some works have shown results confirming the EKC hypothesis while others have defied it.

The first empirical work on the EKC was done by Grossman and Krueger (1991) and they found an upturned "U"-shaped relationship between pollutants and economic growth in the USA. The following are some works and results on the EKC:

Orubu and Omotor (2011) in determining the nexus between per capita income and environmental deterioration, found that suspended particulate matter conform with the EKC hypothesis but organic water pollutants do not (they showed an upward sloping relationship) in Africa. The results of Franklin and Ruth (2012) for USA over a period of 200 years showed a continued upward trend in per capita CO2 emission with economic growth. Ahmed and Long (2012) found results that conform to the EKC between CO2 and growth in Pakistan between 1971 and 2008. Song et al. (2012) testing the presence of the EKC for 30 provinces and cities in China found that EKC does not hold for some provinces and for others they had reached their turning points.

Iwata et al. (2010) provide results supporting the assertion of the EKC hypothesis with CO_2emissions by taking into account nuclear energy in the production of electricity in France.

Roca and Alcantara (2001), in examining the nexus between growth and carbon dioxide (CO_2) emissions rejected the existence of the EKC in Spain from 1972 to 1997. Akbostance et al. (2009) using time series CO_2emissions and per capita income from 1968 to 2003 and panel data from 1992 to 2001 with other 58 provinces found no evidence for the EKC among PM10, SO2 and per capita income. Song et al. (2008)

found an upturned U-shaped nexus between pollutants (waste gas, waste water and solid waste) and economic growth from 1985 to 2005 in China. He and Richard (2010) foundslight proof in favor of the EKC hypothesis in Canada for CO2 emissions. Giovanis (2013) using micro data from Britain investigated the relationship between air pollutants (O3, SO2 and NOx), personal and household income from 1991 to 2009. Using fixed effects model, the paper found no evidence for the EKC, however it found strong evidence for EKC when using dynamic panel data and Bond GMM and logit models.

Others like Narayan and Nayaran (2010), Kaufmann et al. (1998), Schmalensee et al. (1998) and Grossman and Krueger (1995) showed results that affirm the assertion of the EKC while others like Hettige et al. (2000) and Jaunky (2011) gave results showing otherwise.

The empirical works above show that the argument of the EKC hypothesis is inconclusive. Some researchers are of the view that varied conclusions would be made about the EKC as a result of differences in methodology, time period, specific country and the kind of countries in a panel data used (see Grossman and Krueger, 1993; Selden and Song, 1994; Hill and Magnani, 2002).

2.3 Empirical Review

Akinlo (2008) verifies the nexus of the consumption of energy and economic growth using eleven (11) countries of Africa and finds the bi-directional underlying link between economic growth and energy consumption in most countries. Narayan and Narayan (2010) estimate the income elasticity using Panel data method by involving 43 developing countries, and use the short-run and long-run elasticity to confirm EKC. For instance, when income elasticity in the short-run is greater than the longrun income, this means that carbon emissions will decline in the future while the economic performance grows.

The empirical results show that countries in the Middle-East and South Asia have greater long-run elasticities than short-run elasticities, and confirm the presence of an inverted U-shaped EKC in those countries. Apergis and Payne (2010) covered the period 1985-2005 using OECD countries to examine the nexus between economic growth and renewable energy consumption via Panel data approach. Their empirical outcome shows a bi-directional causality within renewable energy consumption and economic performance both in long-run and short-run when the real capital formation and labor force are considered. Sabbori et al. (2012) confirm the presence of an inverted U-shaped EKC between CO2 emission per capita and GDP per capita in Malaysia using ARDL procedure. The author also find the existence of Granger causality between the two variables in the short-run, while the uni-directional causal relationship in which the economic growth leads to rising carbon emissions is established in the long-run. Although Ozturk (2010) summarizes the literature and finds out that there is the absence of consensus for the direction of causality between growth and energy consumption; the author suggests that new approaches and perspectives shall be applied in future research. Recently, the EKC literature extends the study to the scope of sector analysis. Gross (2012) argues that "Simpson paradox" could lead to the inclusive evidence and the inconsistent results for EKC estimation macro and sectoral analysis. Therefore, the causality relationship will depend on the level of data aggregation used in the analysis instead of the true relationship between the series. Gross (2012) analyzed the carbon discharge and economic growth relationship in U.S. for industry, services, transport sectors as well as the macro level applying ARDL model. The author finds the uni-directional and bi-directional causality for service and transport sectors; however, there is no evidence of cointegration among carbon emissions and industrial growth and macro level analysis. Baranzini et al. (2012) discover the link between economic growth and different energy consumption such as electricity and heating oil during 1950-2010 in Switzerland. They demonstrate that there are cointegration relationship both for real GDP growth and heating oil, electricity consumption. Moreover, the long-term income elasticity became insignificance during 1970-2010 and the income elasticity of heating oil turns into negative. These results imply the possibility of decoupling of energy consumption and energy growth.

Zhang and Xu (2012) use the sectoral and regional data during 1995-2008 to discover the link between economic performance and energy consumption in China, and find that the economic growth brings more energy consumption within sectoral and regional analysis. Huang et al. (2008) use the energy efficiency, as the threshold variables for the estimation of the non-linear relationship between energy consumption and economic growths. Bowden and Payne (2009) also investigate the sector-specific causalities between economic growth and energy consumption for the U. S.

Figure 2.2 presents carbon emissions patterns for various sectors in Taiwan during 1981-2012. We observe that the industrial sector accounts for major carbon emissions. Currently, about half of the carbon emissions come from the industrial sector while the transport sector accounts for 14%, 13% and 12% are from each of services and residential sector; 10% from energy sector and only 1% from agriculture sector.

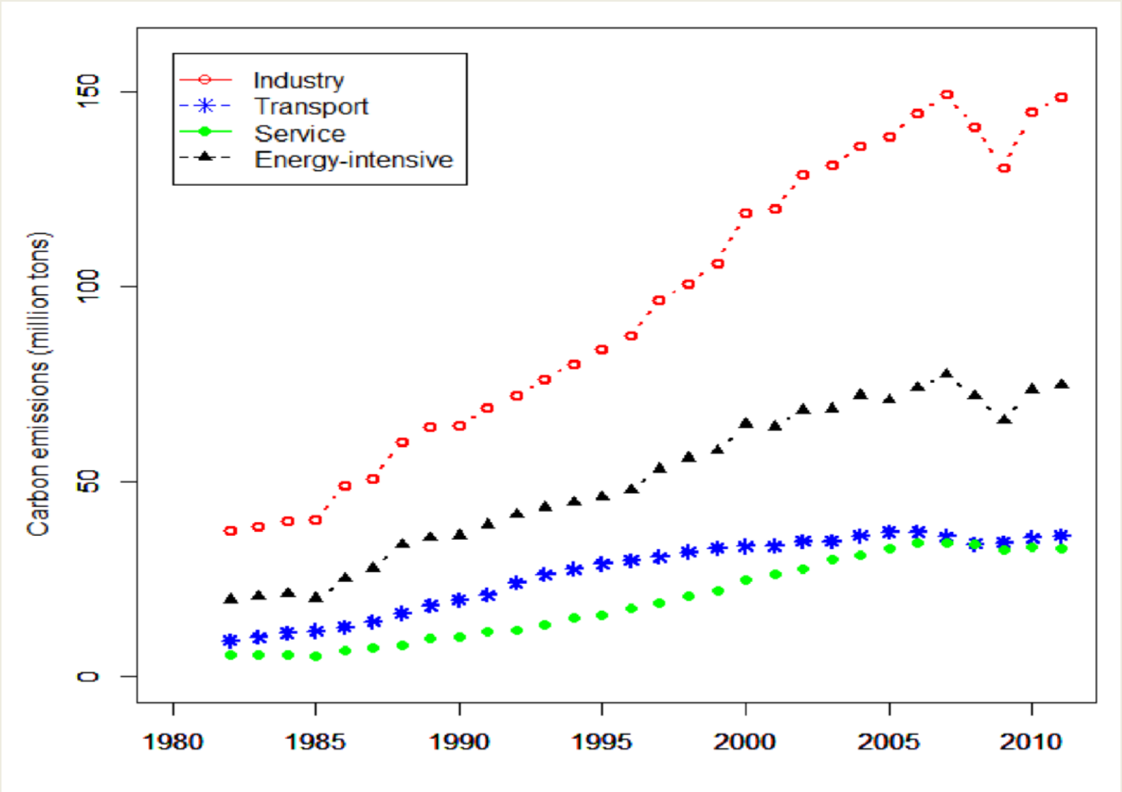

Figure 2.4 Carbon emissions trend for different sectors

2.4 CO_2 Emissions and Climate Change

Human activities in relation to production, consumption and energy usage worldwide are the causes of global climate change (Dhillon and von Wuehlisch, 2013). Considering the works Rehanand Nehdi (2005), climate variation is a long-term change in the climate of a givenlocality, region or the whole planet. Human activities have increased the amount of GHGs in the atmosphere since the industrial revolution and this has led to an increase in the retention of heat in the atmosphere (WMO, 2012). Sunlight reaching the surface of the earth can return to space or be absorbed by the earth. When it is absorbed, the earth radiates some of the heat to the atmosphere. However GHGs like water vapour, CO2 and methane act like a blockade slowing or blocking the escape of heat to space. Hence, the earth becomes warmer. This is termed as the greenhouse effect (US-EPA, 2012). The change in the earth's temperature is known as global warming (WMO, 2012). It comes about as a result of emission of GHGs into the atmosphere (Michaelis, 1993). Between 1750 and 2000,

GHGs have increased by 31% and 151% respectively (VijayaVenkataRaman et al., 2011). This has in turn had effect on the climate of the world.

Carbon dioxide is the main greenhouse gas that is contributing to the modern climate change (US-EPA, 2012). The observed increasing global temperature from the mid 20th century is much possible to be the result of the rising emission of GHGs into the atmosphere by human activities (IPCC, 2007). Svante Arrhenius (1896) predicted that the burning of fossil fuels may increase the emission of CO2 and have a warmer effect on the earth (Pittock, 2003). Increasing levels of CO2 emitted into the atmosphere is vehemently believed to be the key source of human-induced climate change (Rehan and Nehdi, 2005; IPCC, 2007). CO2 concentration in the atmosphere has increased to 360ppm in recent years from 280ppm since the industrial revolution (Stevens, 1994). Increased CO2 emission is considered to be the cause for the warming of the earth's surface (Kessel, 2000). Activities of human presently discharge over 30 billion tonnes of CO2 into the atmosphere every year (US-EPA, 2012). Sun and Wang (1996) using data from 1860 to 1988 found a very strong positive correlation between CO2 emissions and climate change. It is mainly responsible for global warming.

$CO_2$is a gas that occurs naturally, as a burning fuels' by-product and biomass and due to land use changes and other industrial processes (Florides and Christodoulides, 2008). It is emitted due to the burning of coal, oil and gas, changing land use and deforestation (Sun and Wang, 1996). These activities reflect themselves in trade since trade involves transport and production which uses coal, oil, gas and land. Climate change results in harsh hurricanes, floods, and drought which have unfavorable effect on productivity, agriculture, and the society (IPCC, 2001). The recent heat waves, drought, floods and storms occurring in several countries around the globe are all caused by global warming and climate change. These resulted in the rising levels of the sea and this has the potential of increasing coastal erosion, loss of tourism, increased floods and likely loss of lives (Dhillon and von Wuehlisch, 2013). Costello et al., (2009) indicated that global warming will worsen the situation of drought, heat waves and worsen the severity of floods and storms. It will also lead to food insecurity (the harvest of rice and maize is likely to fall between 20% and 40%), decreased water and these will have devastatingeffects on the health of so many people (in relation to cardiovascular diseases, diarrhoea and malaria). They also added that with global warming premature death is expected to increase continually. It leads to short term death of especially those with cardiovascular or respiratory diseases. It leads to increase in asthma, malaria and increases the risk of infectious diseases (Kurane, 2010).

2.5 CO2 Emissions in Ghana

The most abundant greenhouse gas produced and emitted in Ghana is CO_2 (EPA, 2011). From 1989 to 2007, the emission of CO_2(measured in kt) in the country has generally depicted an upward trend with the exception of the years 2000, 2005 and 2007. With 3344kt emission in 1989, CO_2emissions increased till 1999 where it dropped from 6549kt to 6288kt in 2000, after which it increased till 2004 (to 7275kt) and dropped to 6956kt in 2005. It increased to 9578kt in the year 2007 (WDI, 2012). The emission of CO_2in Ghana is about 0.05% of the total global emissions and it places 108th in the world. It corresponds to a total per capita emission of nearly 1MtCO2e per person as of 2006 (EPA, 2011). The Energy sector contributes the largest to emissions in the country accounting for about 41% of the nation's emissions between the years 1990 and 2006. This is followed by the agricultural sector contributing about 38% of the emissions and the waste industry emitting 8% (EPA, 2011). Report by the IEA (2011) indicates Ghana emitted 1.7, 1.5 and 4.8 million tonnes of CO2 from electricity and heat production, manufacturing industries and consumption and transport respectively in 2009. CO2 per population was 0.38 tonnes in 2009 and this represents 109.1% increase from 1990.

In 2000, the total GHG emission in Ghana was estimated to be about 12.2MtCO2e. These gases included CO2, methane, nitrous oxide and per flurocarbons. It represents a 173% increase above the figure for 1990 of -16.8MtCO2e and 96% below of that of 2006 emissions accounting for 23.9MtCO2e. There has been a 242.3% increase between 1990 and 2006. CO2 emissions accounted for -16.3Mt in 1990, 13.3Mt in 2000 and 22.9Mt in 2006 of the total GHGs emitted. CO2 forms the largest portion of GHGs emitted in Ghana. It accounted for 44% of GHGs emitted in 2000. On the average, it accounted for 81.3% of the total GHGs between 1990 and 2006. In Ghana it is mainly emitted from energy, land and forestry usage and industrial processes. In 2000the energy sector, land and forestry and industrial processes accounted for 55%, 37% and 14% of CO2 emissions respectively. Projections of GHGs indicate that their emissions could increase from 7,278Gg to 118,405Gg between 1994 and 2020, rise to 234,135Gg by 2030 and 519,826Gg by 2050. The EPA indicates that though Ghana's emissions of CO2 relative to other countries might be low, it has very high potential in the short to medium term to increase as the economy continues to expand highly especially in the agriculture, forestry, oil and gas sectors.

2.6 Climate Change in Ghana

There is strong evidence supporting the fact that changes in the climate of the earth are associated with the release of GHGs (EPA, 2011). Over the past 30 years temperature in Ghana has risen by 1^0C and projections show that there is a high possibility of temperature increasing between 1.7^0C and 2.04^0C by 2030.

Temperature in the Northern Savannah is likely to rise to as high as 41 oC. A 20 year observed data by the EPA indicates that temperature is rising in all ecological zones and rainfalls have been reducing generally. There is a high probability of sea levels rising by an average of 0.3cm from 3.6cm by 2010 to 34.5cm in 2080.

Climate change has worsened the poverty situation in the country especially in the north where temperatures are already high. It has led to a lower agricultural productivity and periodic flooding in the country. It has also increased the pace of migration of the youth from the north to the south as a result of the low agricultural productivity that comes with climate change. The EPA (2011) also indicates that, it has a potential for; increasing pressure on water and reducing the potential for hydropower, reducing access to water, increasing the incidence of diseases, food insecurity, causing loss of biodiversity, soil fertility and land degradation. All these are as a result of the increasing pace of CO_2 emissions in the country and its effects on the environment (EPA, 2011).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This part of the study centers on the theoretical framework of the model specified for the study. It consists of five sections. Section one provides the type and sources of data considered for the study. The second section looks at the model specification for the study. The third section looks at the definition, measurement and the expected impact of the variables considered for the study. Section four looks at the estimation technique used. The study applied ARDL and the Johansen and Juselius (1990) cointegration method. Section five deals with how the data was analyzed with emphasis on time series analysis.

3.1 Data Type and Sources

Annual time series data from 1974 to 2011 was considered for the first model and 1991 to 2012 was used for the second model of the study. The data used for the study is acquired from the World Bank Development Indicators. Sources of supporting information include published articles, journals, working papers and textbooks. Variables used in the study were carbon dioxide emissions, agricultural sector, industrial sector, service sector (as GDP components) and forest area (a proxy for climate change). The econometric software used for the analysis is eviews 9.0

3.2 Econometric Framework

3.2.1 Specification of Model (1)

Two models are specified for the study. The first model for the study is based on the Environmental Kutznets' Curve (EKC). The EKC is a hypothesis that specifies the nexus between economic indicators of environmental degradation (pollution) and per capita income (Stern, 2004). EKC depicts an inverted u-shaped relationship between per capita income and indicators of environmental degradation.

The general form of the EKC can be written as;

$$E = f(Y, Y^2, Z) \quad \text{.......(1)}$$

E represents environmental degradation, Y is real GDP per capita and Y^2 is income squared. The income squared portrays the quadratic nature of the curve of the EKC; an inverted U-shape (Wang, 2012). Z is a vector of control variables that may contribute to environmental degradation.

In this study there is no vector of control variables as well as the squared of real GDP. The function therefore becomes:

$$E = f(Y) \quad \text{.......(2)}$$

However, RGDP(Y) is decomposed into three sectors. That is, agricultural, industry and the service sectors.Thus;

$Y = (AG, IND, SER)$………………………………………………………… (3)

Replacing Y by its constituents in equation (2) yields the function in equation (4)

$E = f(AG, IND, SER)$………………………………………………………… (4)

The study used CO_2 emissions as a proxy for the environmental indicator (E), where AG, IND, and SER represent real GDP per on sectoral bases. E can therefore be expressedas: $CO2 = f(AG, IND, SER)$ ………………………………………….. (5)

Equation (5) can be written in its multiplicative form as;

$CO_2 = \beta_0 AG^{\beta_1} IND^{\beta_2} SER^{\beta_3} e^{\mu}$ ………………………………………………….(6)

3.2.2 Measurement and Definition of Variables of the Model

The independent variables used in the study have been chosen from theoretical and empirical literature and have been identified to have significant impact on the emissions on CO_2.

Carbon Dioxide (CO_2)

Carbon dioxide is a gas that occurs naturally. It is a by-product of biomass and burning fossil fuel due to changes in land use and some industrial process (Christodoulides and Florides, 2008). It is emitted due to the burning of coal, oil and gas, changing land use and deforestation (Sun and Wang, 1996). It embraces those emittedthrough the consumption of gas, solid and liquid fuels and flaring of gas. The study measures CO_2 emissions in metric tonnes. This measure of CO_2 emissions has been used by a number of researchers (see; (2009), Sharma (2011) and Wang (2012)).

Agricultural Sector

The agricultural sector performance, basically comprises of; hunting, fishing, and forestry, as well as farm animals and crops production. Employed data are in real terms and used as a proxy for the agricultural sector. As a priori expectation we hypothesize positive relationship between CO2 emissions and agricultural sector performance.

Industry Sector

Performance of this sector comprises the manufacturing, electricity, construction, mining, oil and gas and water. Data employed are also in real terms and used as a proxy for the industrial sector. As a priori expectation we hypothesize a positive relationship between CO2 emissions and the industrial sector performance.

Service Sector

This embraces retail and wholesale trade (such as restaurants and hotels), transport, and professional, financial, government and personal services such as education, health care and real estate services. Real terms data are employed and used as a proxy for the service sector. As a priori expectation we hypothesize a negative relationship between CO2 emissions and the service sector performance.

Climate Change

Climate change is a variation in the statistical distribution of weather patterns when that variation last for an extended period of time. Forest area is used as a proxy for climate change in this study.

3.2.3 Unit Root Test.

Having approximated the OLS, we continue to testing for unit root properties of the variables. It is essential in identifying the order of integration of variables and the number of times a variable is differenced to obtain stationarity. In this pursuit, we utilize a unit roots tests. - the augmented Dickey-Fuller (ADF) and the Philip-perron tests are considered. It is imperative to take in consideration that, the ADF test has a homoskedastic error terms assumption, hence the study depend on PP test in order to prevail over the likely challenges of the restricted supposition of the ADF. The PP test has fairly less restrictive assumption with regard to the allocation of the error terms thus correcting for any likely serial correlation and heteroskedasticity in the errors. An essential condition of co integration is that the series must be of the same order and we thus examine this using both the ADF and PP tests which are performed on first in the levels and subsequently in first differences. An appropriate lag length is chosen base on the Schwarz information criterion (SIC).

$$\Delta Y_t = \beta_1 + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \varepsilon_t \text{.................(7)}$$

The null hypotheses of H_0: $\delta = 0$ (the series is nonstationary) is tested against the alternative hypotheses H_1: $\delta < 0$ (the series is stationary).

3.2.4 Co-integration

We employ the Johansen (1988, 1991) multivariate co integration test and the vector error correction model (VECM) after establishing the pattern of integration of the variables. The Johansen multivariate approach to co-integration is a maximumlikelihood estimating approach for the testing of co-integration in the frameworks of multivariate vector autoregressive (VAR) with the aim of identifying a linear permutation which is mainly stationary by using the rank of a matrix–eigenvalues nexus.

Beginning with VAR (k), we define Y_t as a vector (I(1)) – integrated of order one – series denoted by equation (5) specified as follows;

$$Y_t = A_t Y_{t-1} + A_t Y_{t-2} + \dots\dots\dots\dots + A_k Y_{t-k} + \varepsilon_t \text{..............................(8)}$$

Where Y_t and ε_t represent n 1 vectors.

Reparamaterizing equation (8) yields equation (9) below;

$$\Delta Y_t = \sum_{i=1}^{k-1} \Gamma_i Y_{t-i} + \prod Y_{t-1} + \mu_0 + \varepsilon_t \text{.......................(9)}$$

$$\text{where } \prod = \sum_{i=1}^{k} A_i - I \quad \text{and} \quad \Gamma_i = -\sum_{j=i+1}^{k} A_j$$

Johansen (1988) argues that there is n r matrices and α and β each with corresponding a rank *r* in that matrix $\prod = \alpha\beta'$ and $\beta' Y_t$ is stationary. This is feasible if the reduced rank *r* is less than *n*. where *r* is the number of co integrating relationship, α and each column of β are the adjustment parameters in the vector error correction model (VECM) and co integrating vector respectively.

After the control and correction for lagged differences and deterministic series, Hjalmarsson and Osterholm (2007) shows that, for a given *r*, the maximum-likelihood estimator of β given the grouping of Y_{t-1} yields the *r* largest canonical correlations of ΔY_t with Y_{t-1}.

In testing for possible existence of co integration, Johansen (1991) proposes the trace and the maximum Eigen value tests which are respectively defined as;

$$J_{trace} = -T \sum_{i=r+1}^{n} \text{In}(1 - \hat{\lambda}_i)$$

$$J_{max} = -T\text{In}(1 - \hat{\lambda}_{r+1})$$

T denotes the sample and $\hat{\lambda}_i$ represents the *i*th largest canonical correlation.

Needful to note that, the trace statistic tests the null hypotheses of *r* co-integrating relationship against the alternative hypothesis of *n* co integrating vectors where *n* is the number of variables entering the equation. The maximum Eigen value test however, test the null hypothesis of *r* co integrating vectors against the alternativeof*r*+1 co integrating vectors. The critical values are given by Johansen and Juselieus (1990) and Osterwald-Lenum (1992) and are given by the Econometric Views (EViewsVersion 9) which is used in running all the equations in the research work.

The next step involves estimating the following VECM which confines the short-run behavior to its long-run behavior according to the speed of adjustment measured by error corrections term denoted as ECM in equation (10) below.

$$\Delta \ln(CO_2)_t = \alpha_O + \sum_{i=1}^{P} \alpha_{1i}\, \Delta \ln(CO_2)_{t-i}$$

$$+ \sum_{i=o}^{P} \alpha_{2i} \Delta lnAG_{t-i}$$

$$+ \sum_{i=o}^{P} \alpha_{3i} IND_{t-i} + \sum_{i=o}^{P} \alpha_{4i;} SER_{t-i} + \varphi ECM_{t-i} + \varepsilon_{t-i} \ldots\ldots\ldots (10)$$

All the variables still maintain their previous definitions. The error correction term (ECM_{t-1}) represents the residuals that are obtained from the estimated cointegrating model of equation (10)

The coefficients $\alpha_{1i}, \alpha_{2i}, \alpha_{3i}, and\ \alpha_{4i}$ estimate the short-run impact that a change in the independent variable has on the dependent variable respectively. $\varphi$is the coefficient of the error corrections term which implies the speed of the adjustment parameter. It also estimates the speed of of adjustment to long –run equilibrium after a shock to the system. The lag length used in place of P is automatically selected by the econometric software employed.

3.2.5 Specification of model (2)

The second model specified for the study measures the impact of carbon dioxide on climate change using the ARDL approach of co integration.

$$forest_t = f(CO_{2_t}) + \varepsilon_t \quad \ldots\ldots (1)$$

$forest_t$, CO_{2_t} and ε_t denotes climate change, carbon dioxide and variables affecting climate change not captured by the model respectively.

By the linearization of equation (1) above, a cobb-douglas log linear multiplicative function is adopted below;

$$forest_t = \alpha_o (CO_{2_t})^{\alpha_1} u_t^{\varepsilon_t} \quad \ldots\ldots (2)$$

The logarithmic of equation (2) above yields equation (3) below;

$$ln forest_t = \alpha_o + \alpha_1 lnCO_{2_t} + \varepsilon_t \quad \ldots\ldots (3)$$

Given equation (3) in its log form, the coefficient of the variable (CO_{2_t}) in the equation represents its long-run elasticity. $\alpha_1$represents the elasticity of CO_{2_t} with respect to$C\Delta_t$. It specifically captures the degree of responsiveness of $lnforest$ to changes in CO_{2_t}.

3.2.6 Autoregressive Distributed Lag (ARDL) Model

Equation (3) shows the long-run equilibrium relationship. The autoregressive distributed lag co integration procedure propounded by by persaran et'al(2001) is used ii the analysis of the long run relationship and the dynamic interaction of variables used in the model.

The choice of ARDL to estimate the second model was informed by the following reasons:

The ARDL co integration procedure is relatively more efficient when dealing with a small sample data size. The second model for the study covers the period 1991 to 2012.

The ARDL allows for the estimation of the co integration by means of Ordinary Least Square (OLS) method. It only requires the identification of the lag of the model. It therefore differs from other co integration techniques like the johansen co integration technique propounded by Johansen (1990).

The ARDL procedure does not emphasize on the pretesting of the model's variables for unit root unlike other procedures like the johansen co integration technique. It matters not whether the variables in the series are purely I(0), purely I(1) or mutually integrated.

Mostly, time series variables are non stationary. It therefore necessary to verify the stationarity properties of the variables used so as to prevent the risk of spurious regression results. This study adopted the Augmented-Dickey Fuller test of DickeyFuller (1979). The ARDL bounds test is used in the analysis of the long run relationship between the explanatory variables and carbon dioxide emission.

The conditional vector Error Correction Model was estimated as below:

$$\Delta ln(\text{forest})_t = \theta_0 + \beta_1 ln(\text{forest})_{t_{-1}} + \beta_2 ln(CO_2)_{t-1} + \sum_{i=1}^{p} \theta_{1i} \Delta ln\,(\text{forest})_{t-i} \sum_{k=1}^{q} \theta_{2i} \Delta ln\,(CO_2)_{t-k} + \mu_t \dots\dots\dots\dots\dots\dots (4)$$

Definitions of the variables are not different as previously given.Where Δ denotes first difference operator.β_i Denotes the long run multipliers and μ_t denotes the error terms and θ_0 is the drift

3.2.7 Bounds Testing Procedure

These involve three steps: bounds have three steps: the first step is the estimation of equation (4) by OLS to verify to verify the presence long run relationship in the series.

This is ensured through an F-test to determine the join t significance the lagged level coefficients of the variables used.

The hypotheses are:

$H_0 B{:}_1 = B_2 = B_3 = B_4 = 0$ (No co integration or long- run relationship)

$H_1: B_1 = B_2 = B_3 = B_4 \neq 0$

When the F-statistic is above the upper bound, the null hypothesis (no co integration or long run relationship)on the contrary, when the F-statistic falls below the lower bound, we accept the null hypothesis. This implies there is no co integration or long run relationship. Finally, there is an inconclusive result for an F-statistic value that falls between the upper and the lower critical bounds.

The confirmation of a long run relationship paves way for the for the second stage to continue. The long run model is as follows:

$$ln(\text{forest})_t = \theta_0 + \sum_{i=1}^{p} \beta_1 ln\, \text{CO}_{2\,t-1} + \quad + \mu_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Here the orders of the ARDL model are selected for the series using the Akaike Information Criterion.

The final step in this approach is the estimation of an Error Correction Model (ECM). This captures the short run dynamics of the series. The Error Correction Model (ECM) is a means reconciling the short run and long run behavior of economic variables.

The ECM version of the ARDL can therefore be specified as:

$$\Delta\, ln(\text{ forest})_t = \gamma + \sum_{i=1}^{p} \theta_{1i} \Delta ln\, CO_{2_{t-i}} + \mu_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (6)$$

θ_I in the above equation denote the short run dynamic coefficient of the models equilibrium convergence. ECM_{t-1} denotes the ECM and ρ represents the coefficient of the ECM. It captures the adjustment speed for short run deviation to the long run equilibrium due to shock to the system.

CHAPTER FOUR

ANALYSIS AND DISCUSSION OF EMPIRICAL RESULTS

4.0 Introduction

This contains detailed discussions and analysis of results of the study. The chapter has three sections. The first section investigates the properties of the data used in the time series. It entails the ARDL as well as the Johansen and Juselius (1990) test for co integration as well as the unit root test. The following section (2) comes with the presentation and discussion of the estimated long run growth by employing the above mentioned approaches. The last section also contains the presentation and analysis of the results of the ECM for the chosen model.

4.1 The Unit Root Test Results

The stationarity status of the variables (CO_2, AGR, IND, and SER) in the specified model for the study were estimated. This was done for the sake of examimining the impact of sectoral performance on the emission of carbon dioxide and the impact of carbon dioxide on climate change in Ghana by ensuring that the variables were not of order two degree of integration I(2) so as to prevent spurious results. According to Ouattara (2004) F-statistics computations given by Pesaranet al (2001) are incorrect in the presence of

I(2) variables. This is due to fact that the bounds test is laid on the assumptions of order zero I(O) or order one I(1) degree of integration.

The Augmented Dickey-Fuller test forms the basis upon which the stationarity test is conducted. Table 4.1 below portrays the result of the unit root test.

Table 4.1 The Unit Roots Test Results

Variables	Augmented Dickey-Fuller Test	
	Log Level with constant	1st Difference with constant
AGR	0.013073	-1.654541***
IND	-0.075311	-0.905100***
SER	-0.091334	-0.943403***
CO2	0.021651	-2.618769***
FOREST	-9.244***	

The rejection of the null hypothesis is denoted by*** (**)* representing 1% (5%) 10% respectively.

At the log levels, only the forest area variable is stationery but the other variables attained stationarity after their first difference.

By means of the ADF test, the null hypothesis (ie non stationarity) is tested against the alternative hypothesis (ie stationarity).

The first column of table 4.1 indicates that at the log level estimates of the regression, only the forest area variable attain stationarity. This is because; the coefficients of the other variables are above the critical value (that is 10 percent level of significance) at the log level except the forest area variable whose coefficient is below the critical ((that is 10 percent level of significance). Hence, the result of the ADF unit root test shows that the null hypothesis cannot be rejected for the first four variables (at the log levels). This therefore implies that the first four variables are of either order one or higher degree of integration since none is stationary at the log level except the forest area variable.

From the second column of table 4.1, it can be seen that stationarity of the variables is attained after the first difference except the forest which is stationary at the log level. This can be testified by considering the values of the coefficients of the first four variables at the first difference level. The coefficients are either at or below the critical value (that is 10 percent level of significance). Conclusively, the null hypothesis can be rejected and the alternative hypothesis accepted.

4.2 Co integration results

Now that it has been established that the variables are integrated of order one(1) the study goes ahead to test for co integration of the variables (AGRIC, INDUSTRY, SERVICE and CO2) based on Johansen and Juselius (1990) and the forest area CO2 based on the Autoregressive Distributed Lag Co integration Test. These allow for the testing of the long-run equilibrium relationships among the series.

4.3 Johansen Maximum Likelihood Co integration Test

At 5% level of significance, both the trace and maximum Eigen value tests indicate one co integrating equation (CE) among the variables. Thus, the null hypothesis of no co integration relationship among the variables is flatly rejected at the 5% level of statistical significance, using both the maximum Eigen value test and the trace test. The optimal lag length of one was selected based on SC. Table 4.2 presents the Johansen Co integration test results for all the variables in the study;

Table 4.2 Johansen Co integration Test

Trace Test					**Maximum-eigenvalue Test**		
Hypothesized No. of CE(s)	**Eigenvalue**	**Trace Statistic**	**0.5 Critical Value**	**Prob****	**Max-Eigen Statistics**	**0.05 Critical Value**	**Prob****
None *	**0.533967**	**52.14396**	**47.85613**	**0.0187**	**26.72244**	**27.58434**	**0.0641**
At most 1	**0.397619**	**25.42152**	**2979707**	**0.1469**	**17.74026**	**21.13162**	**0.1399**
At most 2	**0.196260**	**7.681263**	**15.49471**	**0.5001**	**7.646781**	**14.26460**	**0.4157**
At most 3	**0.000985**	**0.034482**	**3.841466**	**0.8526**	**0.034482**	**3.841466**	**0.8526**

Trace test indicates 1 cointegratingeqn(s) at the 0.05 level. * denotes rejection of the hypothesis at the 0.05 level**MacKinnonHaug-Michelis (1999) p-values. Max-eigenvalue test indicates no cointegration at the 0.05 level* denotes rejection of the hypothesis at the 0.05 level. **MacKinnon-Haug-Michelis (1999) p-values

4.4 Results of the ARDL or Bounds Test for Co-integration

The ARDL approach actually commences from the estimation of the conditional VECM by OLS so as to ascertain the long run relationship among the variables in the specified model. To achieve the co integration, an F-test, is then conducted to determine the joint significance of the coefficients of the variables at lagged levels. Every variable in the model is taken as dependent variable and regression is run on others. For example, using any of the variables (AGR, IND or SER) as dependent variable and regressing it on the other variables of the series. This is a recurrent action for each of the variables in the series. The number of the regressions estimated after the cycle becomes equal to the amount of variables in the series.

According to Pesaranet al (1997) “this OLS regression in the first differences are of no direct interest” to the ARDL or bounds co-integration test. It is the F-statistic values obtained by regressing each of the variables on the others that is of utmost relevance.

The joint null hypothesis of zero lagged level coefficients is tested via the F-statistics. This means that there is no long run relationship between the variables. The F-statistic is of great essence because it helps in detecting the presence of or otherwise of co integration among the variables in the long-run. The results of the computed Fstatistic in the regression are indicated in table 4.2.

Table 4.3 Bounds Test for Long Run Relationship

	F-statistics	40.59161***
Critical Values	Lower Bounds I(0)	Upper Bounds I(1)
5%	4.94	5.73
10%	4.04	4.78

Since the F-statistics is above the upper bound, it implies the null hypothesis (ie no level relationship) among the variables is rejected. Therefore, there is co-integration.

Based on this, we run our ARDL model.

4.5 The Long-run Relationship

Table 4.4 Estimates of the Long-run Co integration Model 1

Dependent Variable; CO_2			
Regressors	**Coefficient**	**Standard Error**	**t-statistic**
IND	**2.047288*** **	**0.71559**	**2.86098**

AGR	**3.165942*** **	**0.90233**	**3.50863**
SER	**-3.165942*** **	**0.97103**	**-3.26039**

Note:* imply significant at 1% level**

From table 4.4 the result of the long run model 1 indicates that all the coefficients of the variables (in model 1) are greater than one (1). This implies that they are elastic. Therefore table 4.4 is said to contain the estimated long run elasticities when the variables (IND,AGR and SER) are normalized on carbon dioxide. However, all the independent variables are found to be at 1% level of significance.

The estimated long run equilibrium relationship results presented in table 4.4 show a positive relationship between carbon dioxide emission and the industrial sector. It is at 1% level of statistical significance. It indicates that a 1% growth in the industrial sector will lead to 2.0473% increase carbon dioxide emissions. This implies that in the long run a proportionate growth in the industrial sector will lead to a more than a proportionate rise in the emission of carbon dioxide. The results also show a positive relationship between carbon dioxide emissions and the agricultural sector. It is at 1% level of statistical significance. It shows that a 1% growth in the agricultural sector will lead to 3.1659% increase in carbon dioxide emissions. There is therefore more than a proportionate rise in carbon dioxide emissions for a percentage growth in the agricultural sector. Here the estimated long run equilibrium results take a different dimension by portraying a negative relationship between the service sector and carbon dioxide emissions. This relationship is also at 1% level of statistical significance and it implies that a 1% growth in the service sector will lead to3.1659% increase in carbon dioxide emission. This also indicates a more than proportionate decrease in carbon dioxide emission for a percentage increase in the service sector.

4.5.1 Results of the Estimated Long run Equation Using the ARDL Approach From the bounds test results in section 4.3 it is vividly shown that there is long run relationship or co integration among the variables, therefore, equation (6) is estimated using the ARDL (1,0). This is selected base on the Akaike Information Criterion (AIC). The results of the process are indicated in Table 4.5

Table 4.5: Estimated Long run Coefficients using ARDL Approach Dependent Variable: lnforest

Variable	Coefficient	Std. Error	T-Statistic	Prob.
Ln CO_2	-0.010727	0.024617	-0.435767	0.6682
C	4.895800	0.131467	37.239790	.000***

*** (**)* depicts the rejection of the null hypothesis of unit root at 1% (5%) 10% From table 4.5 the coefficients of lnco2 in the long run climate change equation is found to be negative and statistically insignificant. However, it has a depreciating effect on climate change (forest area).

4.6 Vector Error Correction Model (VECM)/Short run Results

The short run behavior (dynamics) of the model is captured by the ECM. The estimated coefficients are therefore the short run elasticities of the model.

The table below4.6 shows the coefficients, t-statistics, probability values and standard error of the VECM model 1

Table 4.6 VECM Model 1

Regressors	**Coefficients**	**Standard Error**	**t-statistics**
D(CO2(-1))	**-0.377128**	**0.19224**	**-1.96180**
D(IND(-1))	**-0.090037**	**0.10955**	**-0.82189**
D(AGRIC(-1))	**-0.030430**	**0.15305**	**-0.19882**
D(SERV(-1))	**0.052821**	**0.13451**	**0.39269**
C	**0.011013**	**0.01765**	**0.62391**

ECT	**-0.028073**	**0.01399**	**-2.00657**

R-squared	0.569832
Adj. R-squared	0.414972
Sum sq. resids	0.238189
S.E. equation	0.097609
F-statistic	3.679650
Log likelihood	37.66283
Akaike AIC	-1.580733
Schwarz SC	-1.136348
Mean dependent	0.014685
S.D. dependent	0.127615

Note: *,,***, represents 10%,5%, and 1% respectively.**

From the table above the results of the short run model 1 estimate an R-squared (R^2) of 0.569832. This implies that all the independent variables (IND, AGRIC, and SERV) account for almost 57.00% of the variation in the dependent variable (CO_2). This is marvelous because it speaks well of the model as it accountsfor a greater variation in the dependent variable (CO_2). The results have an F-statistic of 3.679650 which is quite good as it renders the model fit. The model has passed the following tests: serial correlation, residual diagnostic test of normality and hetereoscedasticity test. These therefore indicate that the model is good enough for the analysis.

From the results, the negative coefficient of the ECT means that the model is consistently dynamic and stable. The ECT is statistically significant. The statistical significance of the ECT coefficient indicates that the coefficients of the long run model under the VECM structure are jointly significant. The ECT has an estimated coefficient of 0.028073 and this means that the system corrects disequilibrium of its previous periods by 2.8% a year. All the coefficients of the short VECM indicate short run elasticities. The first lag of CO_2(CO2(-1)) has a negative coefficient and this implies that a 1% increase in the first lag of CO_2 will lead to 0.377% fall in CO_2 emission in the short run.

There exists a negative relationship between the first lag of the industrial sector (IND(-1)) and CO_2 emissions. The sector has a coefficient of -0.090037.This implies that a 1%

growth in the industrial sector will lead to a 0.090% fall in CO_2 emission. This is inconsistent with the long run model estimates.

The short run model estimated a negative coefficient for the first lag of the agricultural sector (AGRIC(-1)). The -0.030430 estimated coefficient of the sector implies that a 1% growth in the agricultural will lead to 0.030% fall in short run CO_2 emissions. This is also in consistent with the sectors long run model estimates.

The service sector has a positive relationship with CO_2 emissions. It has an estimated coefficient of 0.052821which implies that a 1% growth in the service sector will to 0.053% increase in CO_2 emissions in the short run.

4.3.1 Results of the Error Correction (Short-run) Model for the selected ARDL Model

The ECM is a means of reconciliation between the short run and long run behaviors of an economic variable. The presence of long run relationship among the variables means the estimation of the ECM to find out behavior of the carbon dioxide equation. The short run dynamics of the system is captured by the Error Correction Model. Its coefficients also measure the speed of adjustment to attain equilibrium in periods of shocks to the system. The results of the short run dynamics of the carbon dioxide equation is shown in Table 4.7

Table 4.7 ARDL (1,0) Selected base on the Akaike Information Criterion
Dependent Variable: lnforest

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LnCO_2	-0.000029	0.000069	-0.417935	0.6809
Ecm(-1)	-0.002685	0.000392	-6.851793	0.0000***

*** (**)* depicts the rejection of the null hypothesis of unit root at 1% (5%) 10%

The coefficient of lnCO_2 maintains its negative sign in the short run and still statistically insignificant. This however, shows that in both the short and long runs, lnCO_2 has a depreciating impact on climate (forest area) Ghanaian economy.

CHAPTER FIVE

SUMMARY OF FINDINGS AND RECOMMENDATIONS

5.0 Introduction

Chapter five finalizes the entire study. It provides a summary of the key findings of the study and their policy implication. It also gives recommendations on the findings of the study.

5.1 Summary of the Findings

The application of both economic and econometric tools for the thorough analyses of the effect of sectoral performance on CO_2 emissions in Ghana yielded the following summarized findings.

Using the ADF test, the study conducted a unit root test and found all the variables to be I(1) at the first difference level. The Johansen Co integration Test found a long run relationship among the variables.

An expected theoretically and statistically significant positive relationship was found to exist between the industrial sector and CO_2 emissions in the long-run and and a statistically significant negative relationship in the short-run. Again, a theoretically expected statistically significant positive relationship was found to exist between the industrial sector and carbon dioxide emissions in the long- runand a statistically significant negative relationship in the short-run. It also found a statistically expected significant negative relationship existing between the service sector and CO_2 emissions in the long –runand statistically positive relationship in the short- run.

The second model of the study (using the ARDL Co integration Approach) has a aninsignificant negative relationship between forest area and carbon dioxide emissions.

5.2 Conclusion

This study fills the gap in the literature on sectoral economic growth and carbon dioxide emissions in Ghana. It estimated the impact of the performance of the agricultural, industrial and service sectors of the economy on CO_2 emissions in Ghana. It also estimated the impact of carbon dioxide emissions on climate change.The study used annual time series data obtained from the Development Indicators of the World Bank between the periods of 1977 to 2011 for the first model and between the periods of 1992 and 2012 for the second model. The study employed the use of both the Johansen and juselius (1990) co-integration and the ARDL Approaches to estimate the possible long-run and short-run relationship and effects among the variables in the series.

The ADF test revealed all the variables to be integrated of order 1. The Johansen and Jusselius (1990) co integration test also established that there is co-integration among the variables. Upon achieving co-integration, the study went on to run the VECM. Positive relationship was found between the industrial sector and carbon dioxide emissions in thelong run,implying that growth in the industrial sector increases pollution (CO_2 intensity) in Ghana. However, in the short run growth in the industrial sector depreciatespollution (CO_2 intensity) in Ghana. It also found the agricultural sector to have a positive impact on the emissions of carbon dioxide in the long run and negative impact in the short run. It can be concluded that long run growth in those two-industry and agric- sectors of the economy are pollution intensive in Ghana. The study also found the service sector to have a negative long run as well as positive short run impact on carbon dioxide emissions. This therefore implies that the service sector domination of the economy depreciates pollution (CO_2 intensity) in Ghana.

The study also found a negative statistically insignificant impact of carbon dioxide emissions on climate in Ghana.

5.3 Policy Recommendations

A study about greenhouse gases (GHGs) is very important lately as a result of their contribution to climate change and its consequences on human life, biodiversity, the environment and vegetation. Moreover, the study of carbon dioxide and factors that contribute to its emissions is much more important since it's the largest GHG emitted hence the largest contributor to climate change.

The study recommends that the nation's battle against CO_2 emissions should be geared towards ensuring environmentally sustainable growth in the agricultural sector, since it is found to have positive impact on CO_2 emissions. Therefore all agricultural practices, including traditional practices like bush burning, and the inappropriate use of technologies for irrigation and agro-chemicals that can temper with the sustainability of Agricultural sector must be discouraged.

Further, in order for the agricultural sector to grow to reduce pollution (CO_2 intensity) in Ghana, the climatic consequences must benoted and integrated into the activities of the sector. Advocacy improves knowledge and helps to devise good policies and good agricultural practices. This would also improve the elasticity of production systems to inter- and intra-seasonal climatic changes and to world climate variation.

The study further recommends that the nation engages in less polluting activities in its industrial and agricultural sectors growth expeditions since they are found to increasing impacts on CO_2emissions in the long run . The nation should be mindful of the kind of multinational corporations allowed to produce in it. It should allow corporations whose activities produce relatively less CO2 or virtually do not produce CO2. The study recommends that the nation imports items that are less carbon dioxide emitting into the country.

5.4 Practical Limitations and Suggestions for Future Research

The sectoral contribution to carbon dioxide emissions is a topic very less discussed and investigated into in Ghana. Considering carbon dioxide emissions and its contribution to climate change and global warming, this topic is very essential to be researched into the more. Due to the limitation of data availability for all variables, the study could not cover a very long span. It is therefore suggested that with the availability of data, other researchers should further research into this topic on a very long term span. Lastly, the effects of other variables like FDI and gross fixed capital formation on carbon dioxide emissions can also be investigated.

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APPENDICES

APPENDIX 1: Results of the Johansen Co integration Test

Date: 11/16/15 Time: 08:58
Sample (adjusted): 1977 2011
Included observations: 35 after adjustments
Trend assumption: Linear deterministic trend
Series: CO2 IND AGRIC SERV
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.533967	52.14396	47.85613	0.0187
At most 1	0.397619	25.42152	29.79707	0.1469
At most 2	0.196260	7.681263	15.49471	0.5001
At most 3	0.000985	0.034482	3.841466	0.8526

Trace test indicates 1 cointegratinge qn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.533967	26.72244	27.58434	0.0641
At most 1	0.397619	17.74026	21.13162	0.1399
At most 2	0.196260	7.646781	14.26460	0.4157
At most 3	0.000985	0.034482	3.841466	0.8526

Max-eigenvalue tes t indicates no coin tegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegrating Coefficients (normalized by b'*S11*b=I):

CO2	IND	AGRIC	SERV
0.847963	-1.736025	-2.684602	1.345535
-14.99249	6.256799	-7.975766	-0.160048
5.659080	0.248581	1.594793	-4.155580
-5.473656	0.310984	-0.235586	-1.018361

Unrestricted Adjust nent Coefficien (alpha):

D(CO2)	-0.033106	0.013791	-0.027128	-0.001263
D(IND)	0.104283	0.124362	0.061462	0.002003
D(AGRIC)	0.017613	0.207970	0.193242	0.005422
D(SERV)	-0.002731	0.180934	0.174737	0.000923

Long run relationship

1 Cointegrating Equation(s): Log likelihood 68.51561

Normalized cointegrating coefficients (standard error in parentheses) CO2 IND AGRIC SERV
1.000000 -2.047288 -3.165942 1.586785 (0.71559) (0.90233) (0.97103)

Adjustment coefficients (standard error in parentheses)

D(CO2)	-0.028073 (0.01399)
D(IND)	0.088428 (0.04541)
D(AGRIC)	0.014935 (0.09730)
D(SERV)	-0.002316 (0.08287)

2 Cointegrating Equation(s): Log likelihood 77.38574

Normalized cointegrating coefficients (standard error in parentheses)

CO2	IND	AGRIC	SERV
1.000000	0.000000	1.478788	-0.392866
		(0.24162)	(0.19839)
0.000000	1.000000	2.268723	-0.966963
		(0.54528)	(0.44772)

Adjustment coefficients (standard error in parentheses)

D(CO2)	-0.234838	0.143762
	(0.24427)	(0.10562)
D(IND)	-1.776062	0.597068
	(0.71224)	(0.30798)
D(AGRIC)	-3.103049	1.270649
	(1.60589)	(0.69440)
D(SERV)	-2.714960	1.136807
	(1.36325)	(0.58947)

3 Cointegrating Equation(s): Log likelihood 81.20913

Normalized cointegrating coefficients (standard error in parentheses)

CO2	IND	AGRIC	SERV
1.000000	0.000000	0.000000	-0.733847
			(0.25725)
0.000000	1.000000	0.000000	-1.490088
			(0.40503)
0.000000	0.000000	1.000000	0.230581
			(0.23247)

Adjustment coefficients (standard error in parentheses)

D(CO2)	-0.388359	0.137019	-0.064383
	(0.24609)	(0.09965)	(0.13135)
D(IND)	-1.428245	0.612346	-1.173819
	(0.73514)	(0.29767)	(0.39238)
D(AGRIC)	-2.009476	1.318685	-1.397821
	(1.60016)	(0.64794)	(0.85408)
D(SERV)	-1.726109	1.180243	-1.157082
	(1.34457)	(0.54444)	(0.71766)

APPENDIX 2 Results of the VECM

Vector Error Correction Estimates
Date: 11/16/15 Time: 08:57
Sample (adjusted): 1977 2011
Included observations: 35 after adjustments
Standard errors in ( ) & t-statistics in [ ]

CointegratingEq:	CointEq1
CO2(-1)	1.000000
IND(-1)	-2.047288
	(0.71559)
	[-2.86098]

AGRIC(-1)	-3.165942 (0.90233) [-3.50863]
SERV(-1)	1.586785 (0.97103) [1.63412]
C	13.35174

Error Correction:	D(CO2)	D(IND)	D(AGRIC)	D(SERV)
CointEq1	-0.028073	0.088428	0.014935	-0.002316
	(0.01399)	(0.04541)	(0.09730)	(0.08287)
	[-2.00657]	[1.94716]	[0.15349]	[-0.02795]
D(CO2(-1))	-0.377128	-0.075907	-0.544132	-1.077686
	(0.19224)	(0.62401)	(1.33695)	(1.13869)
	[-1.96180]	[-0.12164]	[-0.40699]	[-0.94643]
D(CO2(-2))	-0.491761	0.210626	-0.646320	-0.907387
	(0.20255)	(0.65749)	(1.40869)	(1.19978)
	[-2.42785]	[0.32035]	[-0.45881]	[-0.75629]
D(IND(-1))	-0.090037	1.373007	2.292354	2.100478
	(0.10955)	(0.35560)	(0.76188)	(0.64890)
	[-0.82189]	[3.86110]	[3.00881]	[3.23700]
D(IND(-2))	0.164742	0.018976	0.522999	0.200024
	(0.11297)	(0.36672)	(0.78570)	(0.66918)
	[1.45825]	[0.05175]	[0.66565]	[0.29891]
D(AGRIC(-1))	-0.030430	-1.007018	-2.487227	-2.521036
	(0.15305)	(0.49682)	(1.06444)	(0.90659)
	[-0.19882]	[-2.02694]	[-2.33665]	[-2.78080]
D(AGRIC(-2))	-0.272148	0.777854	0.346675	0.525511
	(0.16511)	(0.53596)	(1.14830)	(0.97801)
	[-1.64828]	[1.45134]	[0.30190]	[0.53733]
D(SERV(-1))	0.052821	0.114854	0.610265	0.810097
	(0.13451)	(0.43663)	(0.93548)	(0.79675)
	[0.39269]	[0.26305]	[0.65235]	[1.01675]
D(SERV(-2))	0.138850	-1.064801	-1.159491	-1.100632
	(0.13696)	(0.44456)	(0.95249)	(0.81124)

	[1.01383]	[-2.39515]	[-1.21733]	[-1.35673]
C	0.011013	0.027538	-0.027153	0.019118
	(0.01765)	(0.05730)	(0.12277)	(0.10456)
	[0.62391]	[0.48060]	[-0.22118]	[0.18284]
R-squared	0.569832	0.755598	0.644956	0.676558
Adj. R-squared	0.414972	0.667613	0.517140	0.560119
Sum sq. resids	0.238189	2.509775	11.52087	8.357229
S.E. equation	0.097609	0.316845	0.678848	0.578177
F-statistic	3.679650	8.587826	5.045975	5.810402
Log likelihood	37.66283	-3.547638	-30.21707	-24.59898
Akaike AIC	-1.580733	0.774151	2.298118	1.977085
Schwarz SC	-1.136348	1.218536	2.742503	2.421470
Mean dependent	0.014685	0.005800	-0.022086	0.021864
S.D. dependent	0.127615	0.549573	0.976927	0.871753

Determinant resid covariance (dof adj.)	9.00 E-07
Determinant resid covariance	2.34E-07
Log likelihood	68.51561
Akaike information criterion	-1.400892
Schwarz criterion	0.554403

APPENDIX 3.2 Normality Test

VEC Residual Normality Tests
Orthogonalization: Residual Correl
(Doornik -Hansen
Null Hypothesis: residuals are mult
Date: 11/16/15 Time: 09:02
Sample: 1974 2011
Included observations: 35

Component	Skewness	Chi-sq	df	Prob.
1	0.018805	0.002738	1	0.9583
2	0.458262	1.536065	1	0.2152
3	-0.241424	0.443919	1	0.5052
4	0.218210	0.363736	1	0.5464
Joint		2.346457	4	0.6723

Component	Kurtosis	Chi-sq	df	Prob.
1	4.092349	6.092174	1	0.0136
2	5.269765	10.88769	1	0.0010
3	3.536710	2.404887	1	0.1210
4	5.154849	12.70541	1	0.0004
Joint		32.09016	4	0.0000

Component	Jarque-Bera	df	Prob.
1	6.094912	2	0.0475
2	12.42375	2	0.0020
3	2.848806	2	0.2407
4	13.06915	2	0.0015
Joint	34.43662	8	0.0000

VEC Residual Serial Correlation LM Tests
Null Hypothesis: no serial correlation at lag order h
Date: 11/16/15 Time: 09:03
Sample: 1974 2011
Included observations: 35

Lags	LM-Stat	Prob

1	19.39776	0.2486
2	8.115632	0.9453
3	17.14638	0.3762
4	19.21973	0.2574
5	22.45257	0.1292

Probs from chi-square with 16 df.

APPENDIX 4: Results of the ARDL Estimates

ARDL Cointegrating And Long Run Form
Dependent Variable: LNFOREST
Selected Model: ARDL(1, 0)
Date: 02/01/16 Time: 15:10
Sample: 1991 2012
Included observations: 21

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNCO2)	-0.000029	0.000069	-0.417935	0.6809
CointEq(-1)	-0.002685	0.000392	-6.851793	0.0000

Cointeq = LNFOREST - (-0.0107 *LNCO2 + 4.8958)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNCO2	-0.010727	0.024617	-0.435767	0.6682
C	4.895800	0.131467	37.239790	0.0000

APPENDIX 5: Data Used for the Study

YEAR	CO_2	F. AREA	AGRIC	SERVICE	INDUSTRY
1973	51.90476		53.26087	26.52174	20.21739
1974	51.13122		56.17633	23.88025	19.91985
1975	51.48936		53.09996	23.4922	23.40784
1976	52.5		56.37171	22.20704	21.42125
1977	53.35968		60.93629	21.88228	17.17172
1978	52.32558		65.04493	22.06963	12.88544
1979	50.44248		63.39052	23.62724	12.98225
1980	55.06608		60.05614	27.63744	12.30643
1981	52.12766		55.26599	35.19546	9.538554
1982	54.73251		59.35771	34.17511	6.467179
1983	60.36585		..	..	..
1984	51.04167		51.90365	36.94247	11.15388
1985	57.87037		48.43166	33.57695	17.99138
1986	58.51528		48.02699	34.72953	17.24348
1987	55.02008		50.70378	32.94389	16.35233
1988	56.25		49.71706	33.6823	16.60064
1989	57.65125		49.41909	33.7028	16.87803
1990	59.04059	37.91421	45.06751	38.07737	16.85507
1991	60.1626	38.03815	45.55955	37.45791	16.98254
1992	62.32394	38.16208	44.96376	37.58951	17.44676
1993	63.12057	38.28602	41.36654	30.83398	27.79947
1994	60.98361	38.40995	41.97789	30.36408	27.65803
1995	61.02719	38.53388	42.70311	30.55417	26.74272
1996	61.21884	38.65782	43.87821	29.5634	26.55839
1997	62.60163	38.78175	40.05235	31.21624	28.73141

1998	49.63899	38.90569	40.23304	31.54053	28.22643
1999	51.51515	39.02962	39.92779	31.71056	28.36165
2000	57.19921	39.15356	39.41372	32.19899	28.38729
2001	52.06463	39.28013	39.32504	32.53736	28.13759
2002	49.63072	39.4067	39.2114	32.59116	28.19745
2003	47.84615	39.53327	40.23846	32.00407	27.75747
2004	59.96678	39.65984	41.54732	31.39473	27.05795
2005	54.83871	39.78641	40.93535	31.60308	27.46157
2006	46.04592	39.91122	30.40493	48.79568	20.79939
2007	44.92925	40.03604	29.05005	50.20309	20.74686
2008	47.07379	40.16085	30.9619	48.61354	20.42456
2009	54.29815	40.28566	32.90638	47.43678	19.65683
2010	48.43007	40.41048	30.82818	49.36466	19.80716
2011	51.3146	40.53529	26.02256	47.73499	26.24245
2012	52.61514	40.6601	23.60037	47.4616	28.93804