

**AN EMPIRICAL INVESTIGATION OF THE ENVIRONMENTAL
EFFECTS OF ECONOMIC GROWTH, TRADE AND FDI IN SSA: A
PANEL GMM APPROACH.**

BY

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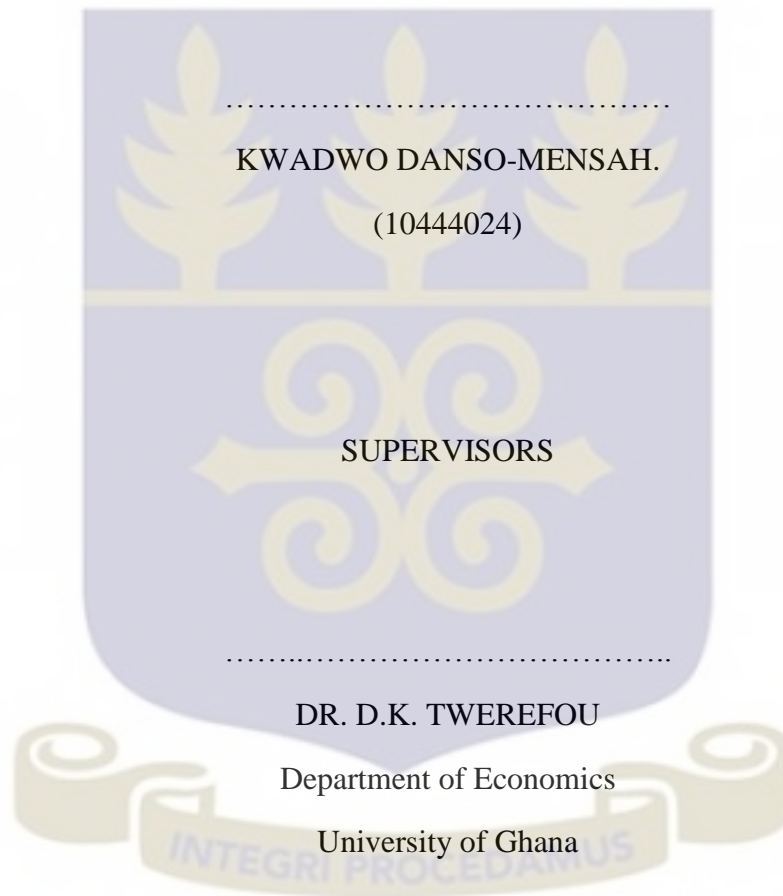
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**THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA,
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DEGREE IN ECONOMICS.**

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DECLARATION

I hereby declare that this thesis is the result of my own original research undertaken by me under the guidance of my supervisors; and that no part of it has been presented for another degree in this university or elsewhere.

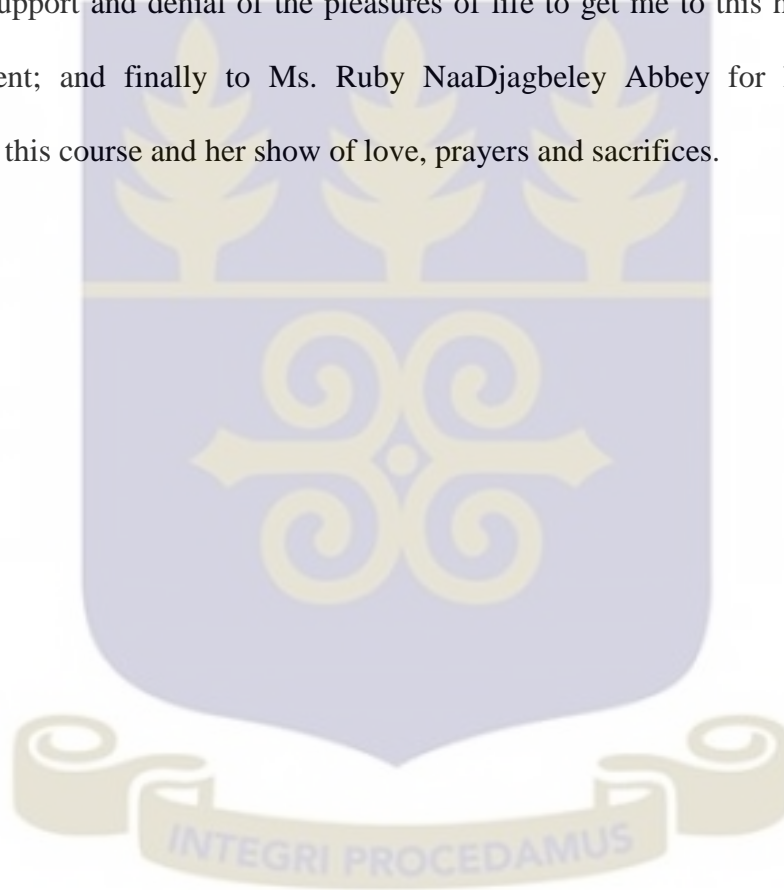


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DEDICATION

This thesis is dedicated to God the father Almighty who is my rock and my defense and unto him belongs all mercy and renders to every man according to his work; to my parents BarimaKwadwoTaboon II (known in private life as Mr. Kwabena Mensah Abrampah) and Madam Gladys Amoah for their immeasurable show of love, care, prayers, support and denial of the pleasures of life to get me to this height of academic achievement; and finally to Ms. Ruby NaaDjagbeley Abbey for her persuasion to undertake this course and her show of love, prayers and sacrifices.



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My gratitude first is to God the father Almighty who has given me the strength both to will and do His good pleasure. Indeed his mercy has consistently met me at my every need and I have not been starved of the right people to give me that which lacks in my life. Unto Him be Glory now and forever more!

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members whose names could not be mentioned here due to lack of space for their encouragement and exceptional demonstration of love to me.



ABSTRACT

Considering the need for economic growth with its accompanying rapid globalization in developing countries, their effects on the environment remain an issue of enormous concern to both economists and environmentalists. This study empirically explores the interrelations between economic growth, trade openness, foreign direct investment and the environment in SSA. The study also examines the joint effect of these variables within the various sub-regional blocks in SSA and whether or not there is evidence of an EKC relationship within the sub-regional blocks. Panel data from thirty-seven (37) sub-Saharan African countries for the period of 1990 to 2013 is used. In order to have a comprehensive outlook of the environment, the study considers two perspectives of the environment, namely environmental quality and sustainability.

Specifically, per capita CO₂ emissions was used as a proxy for environmental quality while Adjusted Net Savings (ANS) was used as a proxy for sustainability. The system GMM estimation technique is employed by the study in order to account for time series variations in the data as well as capture the unobserved country-specific time-invariant effects. The problem of endogeneity in the estimation model is also controlled for with the use of the GMM estimation technique.

The estimation results from this study show a positive relationship between economic growth, trade openness, FDI and environmental quality (CO₂/P) but revealed an inverse relationship with environmental sustainability (ANS) for SSA. The study also found evidence of an EKC relationship for both environmental quality and sustainability in SSA. Furthermore, compared to ECOWAS, the possibility of the joint effect of all the

variables in the sub-regional blocks having an unambiguous improvement on the environment is high for CEMAC and SADC but not in EAC. Finally, the EKC hypothesis is confirmed for per capita CO₂ emissions and ANS in the other regional blocks compared to ECOWAS. However, with respect to ANS, the evidence of an EKC relationship is only significant for SADC. The study makes some practical recommendations necessary for the region to mitigate the adverse effects arising from the estimation results.



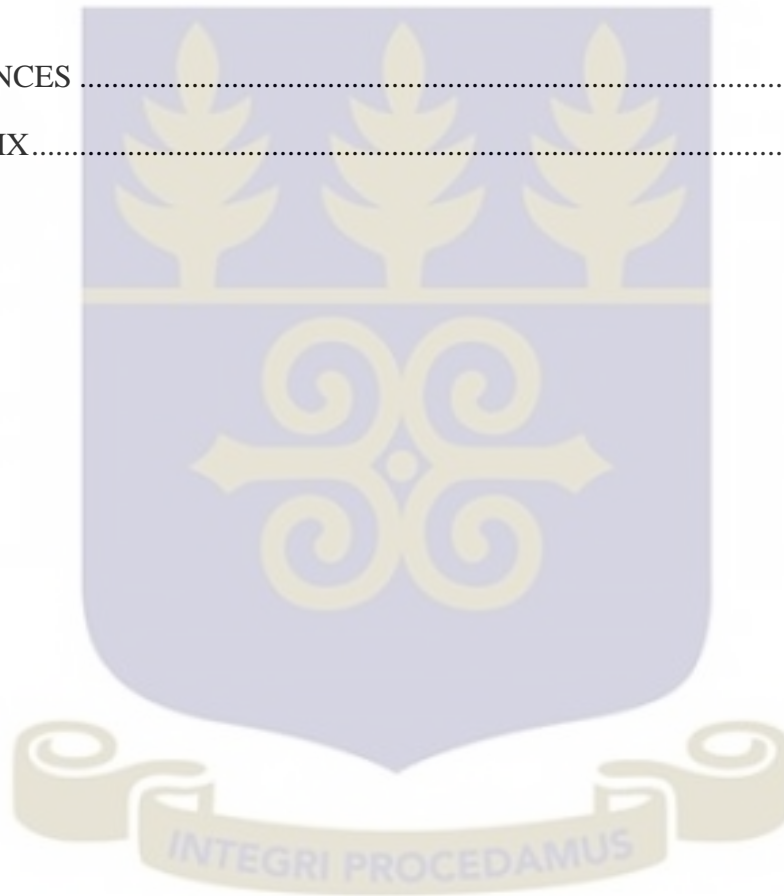
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LIST OF ACRONYMS

| | |
|-----------------|--|
| ADF | Augmented Dickey Fuller |
| ANS | Adjusted Net Savings |
| ARDL | Auto Regressive Distributed La |
| BRIC | Brazil Russia India China |
| CEMAC | Central African Economic and Monetary Community |
| CFC | Chlorofluorocarbon |
| CH ₄ | Methane |
| CIESIN | Center for International Earth Science Information Network |
| CIVLIB | Civil and Political Liberties |
| CO ₂ | Carbon dioxide |
| CO | Carbon Monoxide |
| EAC | East African Community |
| ECM | Error Correction Model |
| ECOWAS | Economic Community of West African States |
| EDP | Environmentally Adjusted Net Domestic Product |
| EDI | Environmental Degradation Index |
| EKC | Environmental Kuznets Curve |
| EPA | Environmental Protection Agency |
| ESI | Environmental Sustainability Index |
| EU | European Union |
| FDI | Foreign Direct Investment |
| FE | Fixed Effects |
| GEMS | Global Environmental Model System |

| | |
|------------------|--|
| GDP | Gross Domestic Product |
| GDI | Gross Domestic Income |
| GED | Global Environmental Degradation |
| GEKC | Global Environmental Kuznets Curve |
| GHG | Green House Gases |
| GMM | General Method of Moments |
| GNI | Gross National Income |
| GS | Genuine Savings |
| Gt | Gigatonnes |
| HDI | Human Development Index |
| IV | Instrumental Variable |
| LCU | Local Currency Unit |
| LM | Lagrange Multiplier |
| MDG | Millennium Development Goal |
| MEKC | Modified Environmental Kuznets Curve |
| MENA | Middle East and North African |
| N ₂ O | Nitrous oxide |
| NAFTA | North American Free Trade Agreement |
| OECD | Organization for Economic Co-operation and Development |
| OLS | Ordinary Least Squares |
| OLG | Overlapping Generation |
| PCA | Principal Components Analysis |
| PHH | Pollution Heaven Hypothesis |
| PPP | Purchasing Power Parity |
| RCH | Resource Curse Hypothesis |

| | |
|-----------------|---|
| RE | Random Effects |
| SADC | South African Development Community |
| SD | Sustainable Development |
| SO ₂ | Sulfur dioxide |
| SPM | Suspended Particle Matter |
| SSA | Sub Saharan Africa |
| TSP | Total Suspended Particulates |
| UN | United Nations |
| UNDP | United Nations Development Programme |
| UNEP | United Nations Environment Programme |
| WCED | World Commission on Environment Development |
| WDI | World Development Indicators |



CHAPTER ONE

INTRODUCTION

1.0 Background

The quest for sustainable growth and development has been a long standing issue of enormous concern to the world. In the light of increasing globalization, environmental concerns have captured serious attention of both governments and international organizations. The growth and development of a nation have been found to be determined by a number of factors. Some of the key growth enhancing factors includes free trade and foreign direct investment (FDI). These factors have some impacts on environmental quality and sustainability.

Roughly valued at six trillion dollars per year, international trade could be a huge force for sustainable development. They can create the necessary conditions for poverty alleviation through the opening up of new markets, exposing domestic firms to international practices and bringing new investment and growth. However, the outlook on free trade and sustainable development today appears daunting, with a lack of substantive policy progress in many areas.

The trade-environment debate over the past decade has involved mixed conclusions. One school of thought claims that increased trade undermines environmental quality through scale effects. This school of thought comprising of social and physical scientists like Meadows et al. (1972) believe that increases in consumption and production activities entail larger inputs and raw materials and further generates larger quantities of waste by-

products. Counter claims are that free trade enables countries to grow out of their environmental problems through its technique effect. Proponents of this thought such as Antweiller (2001) and Beckerman (1992) believe that the environment will only become better as a country develops. However, it is the latter view that has been embraced by trade advocates, praised by economic theory and supported by recent empirical findings.

On the FDI debate, it has been argued by Kamara (2013) that developing countries particularly those in SSA have low savings making private foreign capital the major source of capital for investment. Most developing countries prefer FDI to other forms of private foreign capital because of its perceived role in promoting economic development through job creation, technology transfer, increased productivity and economic growth. Moreover, FDI proves to be relatively stable and less sensitive to economic fluctuations compared to portfolio investment, which many believed triggered the Asian economic crises of 1997.

Using FDI data from UNCTAD, Kamara (2013) further argues that SSA has seen a substantial increase in FDI flows particularly in the last decade which saw FDI flows to the region more than double from an annual average of US\$ 14.9 billion between (2001–2005) to US\$ 30.3 billion between (2006–2010). Within the same period, per capita FDI to the region has almost doubled from an average of US\$ 20.60 to US\$ 37.04. In 2011, FDI flows to the region shot to a record of 35.0 billion dollars from the 27.4 billion dollars posted in 2010 with West Africa receiving a bulky 46 per cent. This is higher than the 34.7 billion high recorded in 2008.

Much of the literature have hinted that today, many developing countries including countries in SSA are actively seeking to improve the attractiveness of their domestic economies to FDI and trade in an attempt to realize the gains that are inherent in opening up domestic economies. In particular, Morris (2008) reported that SSA countries are incentivized towards more and greater openness following the recent remarkable growth rates recorded by economies of East Asian countries which is supposedly attributed to increased openness of their economies. Although trade and FDI inflows are desirable particularly for developing countries, questions still remain concerning their effects on the environment and sustainable development. Unfortunately, in an effort to accelerate economic growth, environmental considerations have been kept as a secondary objective in policy making in most of the developing countries including SSA.

This poor emphasis on environmental protection could lead to serious environmental problems in developing countries, threatening their sustainable future. The diversity of unresolved globalisation and environment issues currently in multilateral, regional and bilateral negotiations, coupled with the challenge of implementing an equitable rules-based global trading system that works in agreement with national, bi-lateral and regional policies and agreements presents enormous challenges for all countries. In analyzing the environmental effects, one group of studies has analyzed the impact of trade on environment via economic growth. This approach of looking at the impact of economic growth on environment is popularly known as Environmental Kuznets Curve (EKC).

Following the observation of Kuznets (1955), the EKC hypothesis posits that, in the early stages of economic growth, environmental awareness is low or nearly negligible and environment friendly technologies are almost nonexistent. This causes environmental degradation to increase with growing income. However, as economies become wealthier, demand for better environmental standards increases leading to improved environmental conditions. This relationship can be shown by an inverted U-shaped curve. Under this hypothesis, developing countries are forced to exploit their environment and cannot afford to protect the environment from pollution as they begin to develop. But as they carry out this exploitation, these developing countries reach a level of income where they are able to afford environmentally friendly production methods and can increase government resources devoted to protection of the environment. At that point, increasing per capita income is associated with an increase in environmental quality and sustainability (Perkins, 2001).

The second group of studies including He (2006) and Agarwal (2012) has attempted to investigate the impact of FDI on the environment in developing countries. The impact on environment could be through the shifting of dirty industries from the advanced countries to the developing countries and due to their comparatively lower levels of pollution norms.

If countries have differences in environmental regulations or enforcement, then countries will invest in dirty industries in countries with no strict environmental regulation (Kleemann et al, 2013). This has been described as the Pollution Heaven Hypothesis (PHH). There is a pollution heaven effect when a tightening up of pollution regulation will, at the margin, have an effect on plant location decisions and trade flows. Whereas

the pollution heaven effect has strong theoretical support, that of the pollution heaven hypothesis is, in contrast, quite weak. This is because many other factors, in addition to pollution regulation, affect trade and FDI flows. If these other factors are sufficiently strong, then it is quite possible for there to exist a pollution haven effect, but have the pollution haven hypothesis fail.

In general, the environmental impact of economic growth can be assessed by scale, composition, and technique effects. While the scale effect refers to the overall size of the economy, the composition and technique effects represents the share of dirty industries and relative emissions intensity respectively. Based on the signs from and magnitude of all three effects, these frameworks can be used to model the effects of income growth on the environment (Zhang 2012). Whereas the scale and technical effects are generally considered negative and positive respectively, the direction of the composition effect appears to be inconclusive, resulting in competing theories that attempt to explain which countries attract dirty industries when liberalization policies are undertaken.

1.1 Problem Statement

The concept of economic development has been looked through a different spectacle after the publication of the Brundtland commission report in 1987 by raising the issue of sustainable development. The Rio conference (1992) also hugely contributed to the understanding of the concept that instigated most countries to chart policies in achieving sustainable development by considering environmental effects of developmental activities.

Given the current high poverty levels of the sub-Saharan Africa region, the drive to pursuing growth is most crucial. This has led to the implementation of various policies aiming to improve their economies by allowing open trade and increasing the attractiveness of the economy to foreign direct investment. Ackah and Morrissey (2005) have revealed that most of the economic policies implemented during the early 1980s and even to date have largely been geared towards the lowering of trade barriers and the increasing of the international competitiveness of domestic exports.

This can be attributed to the shift from import substitution strategic policies to an export-oriented approach which has accounted for the apparent success of economies that has already embraced it (Loots and Kabundi, 2012). In particular, Morris (2008) has reported that countries in SSA are aggressively seeking more and greater openness following the recent remarkable growth rates recorded by economies of East Asian countries which is supposedly attributed to increased openness of their economies.

Given the considerable need and desirability of trade and FDI for SSA, there still remain questions concerning their effects on the environment and sustainable development. It has been established in theory that, the use of natural resources or environmental resources is inevitable in the promotion of economic growth and development. This implies that, in as much as we desire to be productive, we should also expect some level of tamper with the environment. Stern (2004) report that a 1% increase in scale (economic growth) results in a 1% increase in emissions. In a related study, Stern (2008) estimated that the costs of not taking action will correspond to at least 5% of global GDP each year. This stands to reason that, there is the need for sound, efficient and sustainable management of the environment.

Globally, CO₂ emissions have been a major interest to environmentalists and environmental economists as compared to other emissions such as SO₂, NO_x and so on. Human beings produce CO₂ by burning fossil fuels such as coal, oil and gas in their commercial and domestic activities. Given the growing usage of fossil fuels for the production of goods and services, (CO₂) emissions have increased significantly in the past century (Boopen and Vinesh, 2010) and accounts for about 72% of emitted greenhouse gases (Sanglimsuwan, 2011). According to the World Bank, CO₂ emissions in SSA were reported at 682342.86kt in 2008. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. Averaging between 0.8 and 0.9 during the early 1990s, CO₂ emissions(metric tons per capita) in Africa has remained fairly constant even in the late 1990s and early 2000s. In 2010 however, the average CO₂ emission (metric tons per capita) was estimated to have fallen marginally to 0.8 (WDI, 2013). Despite this progress, there is more than enough room for the region to reduce the emission of CO₂ drastically considering its hazardous nature.

The amount of CO₂ emissions embodied in international trade cannot simply be ignored; they amounted to 3.46 Gt in 2009, which corresponds to 12% of the global emissions. A huge share of the world's environmental damage is as a result of growing scale of global economic activities of which international trade and FDI flows forms a considerable portion (UN, 2000). Globalization is likely to increase trade volumes, expand economic activities and affect environmental quality (Vutha and Jalilian, 2008). Su and Ang(2011) has opined that emissions in a country's globalization processes measured as a percentage of its total emissions are increasing overtime. Most empirical works have confirmed that

trade and FDI has significant effect on the emission of carbon (see Jayanthakumaran et al., 2012; Peters and Hertwich 2008, Wang and Watson 2007).

Within the realm of policy, it would be accepted that in the design of national and international environmental regulations, a critical look at the implications of globalization is considered. However, the majority of proposals for appropriate climate policies consider emissions trade schemes, technology cooperation, reforms of fossil fuel support subsidies and carbon pricing (Stern, 2008; OECD, 2012), and only a few proposals paid direct attention to the consequences of international trade (Peters et al., 2011). Knowledge of the directional effects of trade and FDI on the quality and sustainability of the environment stands crucial in the formulation and implementation of proper globalization policies as well as environmental – friendly growth policies. In spite of this, the evidence for Sub Saharan Africa (SSA) is sparse, both at the theoretical and empirical level as literature has not adequately interrogated the effects of these liberalization policies (trade and FDI) on environmental quality and sustainability.

Another area that has received very little attention in the environment debate is the issue of sustainability. This vital area of the debate has also received very scanty exploration. The very few studies that have employed indicators of sustainable development report findings that are mixed with almost non for sub-Saharan Africa. Whiles some studies such as Costantini et al. (2006) and Abdulia et al. found evidence for the EKC, others such as Munasinghe (1999) showed a steeper upward sloping curve for the EKC. A major challenge has to do with the question of how to measure progress towards sustainable development.

A widely accepted indicator for (though a weak indicator) sustainability based on the concepts of green national account and the Hartwick rule is the adjusted net saving (ANS). This indicator provides a measure of a country's sustainability by measuring the change in comprehensive wealth during a specified accounting period. Given that adjusted net savings (% of GNI) in the region was last measured at -2.4% in 2010 according to the World Bank, there is an urgent need to seek for policy measures that can make positive impacts in order to meet the recommended standards and knowing the contributions of economic growth, trade and FDI will surely help in this direction.

In view of the above discussions, questions that arise are:

- Is there a relationship between economic growth, trade, FDI flows and environmental quality and sustainability?
- Does the EKC actually exist for CO₂ emissions and Adjusted Net Savings?
- Do the possible differences between the sub-regional blocks in SSA indicate any systematic dynamics regarding the relationship between economic growth, FDI, trade and the environment?

1.2 Research Objectives

The objectives of this study are;

- Investigate the relationship between economic growth, trade, FDI and environmental quality and sustainability in SSA.
- Investigate the existence or otherwise of the EKC for CO₂ and Adjusted Net Savings.

- Investigate whether the possible differences between the sub-region in SSA has any systematic influence on the quality and sustainability of the environment.

1.3 Significance of the Study

The past few decades has seen significant influence in development ideas in SSA due to environmental concerns within the region. Since economic expansion is highly necessary and demanded exploitation of the environment, Agenda 21, drawing on the Brundtland report (WCED, 1987), noted that in order to satisfy current needs and preserve resources for the future, new modes of development were needed. With current interest and debates about sustainable development in SSA, there is now a growing interest to explore the relationship between economic growth, globalization (free trade and FDI) and environment. In light of the above discussion, the study is considered significant in three reasons.

Firstly, this study introduces the issue of sustainability into the environmental debate. Most of the empirical works on the globalization-environment relationship in the sub-region (e.g Omojolaibi 2010; Abimbola and Bello 2010; Omisakin 2009) have only concentrated on pollution. As a form of innovation, this study enriches the debate by investigating the effects of economic growth and globalization on both environmental quality and sustainability. The study employs an environmentally adjusted income measure to explore whether trade liberalization and FDI would still be beneficial for developing countries (SSA), after controlling national income for potential harmful

effects on the environment. This will enable researchers to have a comprehensive outlook of the dynamics of the environment so as to inform policy formulation.

Secondly, by exploring the performance of the environment in the four main sub-regional blocks in SSA, we are able to better understand the dynamics/behavior of the environment across the sub-regional blocks within SSA based on their state of development. Although debatable, possible differences between regions could arise due to different development paths (for example based on natural resource extraction, traditional industrial activity, or service industries), cultural differences, dissimilarities in climate and natural resource endowment, or different approaches towards environmental protection in the policy agenda. By this, the study is able to assess whether the state of development of a particular sub-region in SSA coupled with its peculiar characteristics has any systematic influence on the quality and sustainability of the environment.

Lastly, this study will further stimulate the globalisation-environment debate and will be of considerable importance to national and international environmental policy. Policy makers within the globalization sector will be better informed as to whether the current liberalization policies undertaken in the sub-region possess some kind of threat to the environment.

By this both trade and financial advocates will be well informed as to whether encouraging greater inflows is one of the keys in reducing carbon dioxide emissions in the region and also improving the region's adjusted net savings (ANS) values. Previous studies such as Jalil and Feridun (2010), Muhammad et al (2011) and so on have found financial development to be helpful in reducing carbon dioxide emissions using a time

series approach. This studies will equip policy makers with a comprehensive regional perspective.

Also the results from the study will inform policy about which sub-region from the sub-regional block analysis is able to better sustain the environment in the face of increased globalization and what lessons could be learnt. Thus, the justification of the study is to provide policy makers in the SSA region evidence on the environmental effects of globalisation to enable them take appropriate policy action to mitigate the adverse effects of these policies on the environment through the promotion of policies which are friendly to the environment.

1.5 Organization of the Study

The study is organized into five main chapters. The first chapter focuses on the general introduction to the study which includes the background of the study, problem statement and research questions, research objectives and significance of the study. Chapter two is devoted to the review of both theoretical and empirical literature. Chapter three captures the Methodology, the empirical model and sources of data to be used by the study. Chapter four focuses on the estimation, analysis and discussion of the empirical results of the study. Chapter five provides the summary, conclusions and policy recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.0 INTRODUCTION

This chapter focuses on the review of literature on the topic for the study. The chapter presents a review of the theoretical underpinnings of the EKC hypothesis and sustainability. In addition, it reviews empirical studies with specific focus on the role of FDI and trade on the income-environment relationship. The chapter also reviews some empirical studies relating to issues of sustainability and the EKC framework.

This chapter will therefore proceed in two broad sections. The first section reviews the theoretical literature of the topic while the second section looks at the empirical studies conducted on the theme. The empirical review will consider the following: a general review of the EKC, a review of the various hypotheses of the EKC, a review of trade and income-environment relationship, FDI and income-environment relationship, the pollution heaven hypothesis and the EKC and lastly a review on the EKC and sustainability.

2.1 Theoretical Literature

2.1.1 Theoretical Underpinnings of the EKC Hypothesis

It has largely been argued in the environmental realm that only the rich can afford to be green. Although the trend seems to be changing, the environment is the least on the list of people's priorities after considering a stable income, basic housing, energy and so on.

The demand for post-materialist needs only become necessary after countries have developed and citizens enjoy a higher standard of living. The work by Simon Kuznets on inequality in the 1950s has indeed been the catalyst that has fueled the arguments.

At the 67th annual meeting of the American Economic Association in 1954, Simon Kuznets presented his well-known paper *Economic Growth and Income Inequality*, for which he was awarded the Nobel prize in 1971 (Kijima et al., 2010). His argument was that in the early stages of industrialization, pollution and environmental damage will rise sharply. However, as GDP increases, it will eventually peak and begin to fall, as governments begin to legislate for pollution controls and as the economy moves towards services rather than industry. This gives us an inverted U curve known as the Environmental Kuznets Curve (EKC). Following this, most of the works on the environmental effects of growth has been analyzed within the framework of the EKC.

In 1972, the Club of Rome's report "The Limits to Growth" launched a huge discussion about the sustainability of economic growth. They argued that the finiteness of environmental resources would constrain the possibilities for economic growth. For this reason they demanded a steady-state economy with zero growth, to avoid the world economy reaching its physical limits regarding nonrenewable resources and excessive pollution (Kaika and Zervas, 2013). The view was soon challenged on empirical and theoretical grounds. The findings of Kuznets have turned the limits to growth fears of the 1970s upside down. As the Palgrave Dictionary of Economics says, with the EKC we can "refute the claim that environmental degradation is an inevitable consequence of economic growth."

The EKC is named after Kuznets (1955) who hypothesized that inequality in income initially will rise but then will eventually fall as economic development proceeds. Grossman and Krueger (1991) are credited with the emergence of the EKC concept in the early 1990s with their study of the potential impacts of NAFTA (North American Free Trade Agreement). The concept gained its popularity through the World Bank's World Development Report 1992 (IBRD, 1992) which argued that: "the view that greater economic activity inevitably hurts the environment is based on static assumptions on technology, tastes and investments" (p.38) and that "As incomes rise, the demand for improvements in environmental quality will increase, as will the resources available for investment" (p. 39). Many more have given credence to the existence of the EKC for various pollutants with Beckerman (1992) claiming that there is clear evidence that, although economic growth usually leads to degradation, in the early stages of the process, in the end the best- and probably the only- way to attain a decent environment in most countries is to become rich" (p. 491). Lomborg (2001) has relied heavily on the 1992 World Development Report to argue the same point in his book, *The Skeptical Environmentalist*.

Advocates of the EKC hypothesis have mentioned factors such as scale, changes in economic structure or product mix, changes in technology, and changes in input mix as the proximate causes of the EKC relationship, as well as environmental regulation, awareness, and education as underlying causes which can only have effect through the proximate variables. Specifically, Panayotou, (1993, p. 1) opined that at higher levels of development, structural changes towards information-intensive industries and services, coupled with increased environmental awareness, enforcement of environmental

regulations, better technology and higher environmental expenditures, result in leveling off and gradual decline of environmental degradation. Stern (2004) also argues that although any actual change in the level of pollution must be as a result of the changes in one of the proximate variables, those variables may be driven by changes in underlying variables that also vary over the course of economic development. By making various assumptions about the economy, various studies have developed theoretical models of how preferences and technology might interact to result in different time path of environmental quality.

Lopez (1994) and Selden and Song (1995) assume infinitely lived agents, exogenous technological change and that pollution is generated by production and not by consumption. According to Lopez (1994), when producers free ride on the environment or pay fixed pollution prices, growth results unavoidably in higher pollution levels but when producers pay the full marginal social cost of pollution they generate, then the pollution-income relationship depends on the properties of technology and of preferences. He further argues that pollution increases monotonically with income when preferences are homothetic but with non-homothetic preferences, the faster the marginal utility declines with consumption levels and the higher the elasticity of substitution between pollution and other inputs, the less pollution will increase with output growth. If the values of the parameters of technology and preferences are empirically plausible, then an inverted U-shaped pollution-income relationship will be achieved.

This has heavily been relied on by Panayotou (2000) to explain why damage is more evident to consumers in the case of pollutants such as SO₂ and particulates as compared to pollutants such as CO₂ where damage is less evident to consumers. He further explains

that in the case of SO₂ and particulates, pollution prices are near their marginal social costs and turning points and are obtained at relatively low income levels whereas for CO₂ where damage is less evident to consumers, pollution prices are far from their marginal social costs and turning points are obtained at much higher income levels. In the work by Selden and Song (1995), an inverted U-path for pollution and a j-curve for abatement that begins with fixed capital is achieved. Their study concluded that for development to reduce the carrying capacity of the environment, the abatement effort must increase at an increasing rate to offset the effects of growth on pollution.

Others such as John and Pecchenino (1994), John, Pecchenino, Schimmelpfennig, and Schreft (1995), and McConnell (1997) developed models based on overlapping generations where pollution is generated by consumption rather than by production activities.

For the study of John and Pecchenino (1994) and John et al. (1995), the models proposed that the economy is characterized by declining environmental quality when consumption levels are low, but given adequate returns to environmental safeguarding, environmental quality increases and even ameliorates with economic growth. In these overlapping generation models, pollution is generated by consumption activities and is partially incorporated as the current generation considers the effect of pollution on its own (current generation) welfare but not on the welfare of future generations.

In his study, McConnell (1997) examined the role of income elasticity of demand for environmental quality in explaining the inverted U-shaped pollution-income relationship by adapting a static model of an infinitely lived household (based on overlapping

generations) in which pollution is generated by consumption rather than production and pollution is reduced by abatement. The study asserts that the higher the income elasticity of demand for environmental quality, the slower the pollution growth when positive, and the faster the pollution growth when negative. The study concludes that even though preferences consistent with positive income elasticity of demand for environmental quality are helpful, they are neither necessary nor sufficient conditions for the inverted U-shaped pollution-income relationship.

Further, endogenous technical change is allowed by Stockey (1998). His study investigated how different production technologies affect environmental quality. He concludes that, the pollution level decreases after the representative agent starts using a more environmental friendly technology. In a related study, Hartman and Kwon (2005) considered an endogenous growth model with two factors of production: physical capital that generates some pollution and human capital that entails no pollution. Due to the possible substitutability between clean human capital and physical capital in the production of the final output in Hartman and Kwon (2005) model, the growth of pollution which eventually chokes off economic growth in Stockey (1998), does not happen in the model of Hartman and Kwon (2005). Stockey's (1998) model has been generalized by Lieb (2001) and argues that satiation in consumption is needed to generate the EKC.

It has been argued by Andreoni and Levinson (2001) that none of these special assumptions is needed and that economies of scale in abatement is enough to generate the EKC. This idea was developed within a one-good endowment model which revealed that as the scale of output increases, firms move to cleaner techniques of production even with

constant pollution taxes. The scale effect creates its own technique effect even in the face of zero pollution response to higher incomes. Thus, if the abatement technology is characterized by increasing returns to scale, then high income individuals/countries can easily attain more consumption and less pollution than low income individuals/countries giving rise to an optimal inverted U-shaped pollution-income curve. They conclude that different pollutants have different abatement technologies and as a result, their corresponding optimal pollution-income curve may or may not be U-shaped.

In a much recent study, Shirota and Kamogawa (2007) extended and theoretically developed the dynamic neoclassical Ramsey-Koopmans growth model and also included energy consumption into the model. They defined new conditions for the EKC situation and called it “the green golden rule”. A key critique of their model is that some parameters introduced into their model required definitions which could not be found in the theoretical literature even though their results are in consonance with empirical studies that did not conclude the existence of the EKC hypothesis for energy and CO₂ hypothesis. Although most studies model the emissions of pollutants, very few such as Lopez (1994) and Bulte and Van Soest (2001) have developed models for the depletion of natural resources such as forests or agricultural land fertility.

Mariani et al. (2010) study an overlapping generation (OLG) model in which they describe the interrelation between health and environment. They found out that agents who expect a long life-span are more concerned about future impacts on the environment; therefore they spend more on environmental quality. Their study generated an EKC relationship after including human capital in the production function.

Egli and Steger (2007) investigated the effectiveness of public policy measures. By assuming increasing returns in abatement, they came to the conclusion that it is optimal to subsidize abatement effort instead of taxing pollution. Their model also offers an opportunity for an N-shaped EKC by including the cube of income.

Pyndick (2007) claims that the former deterministic models are not able to capture the existing uncertainties in environmental changes, thereby he triggered a range of real option approaches (Di Vita, 2007; Kijima et al., 2011). Uncertainties can exist regarding the future cost and benefits of environmental policy. For instance, environmental damage caused by global air pollution does not necessarily follow a linear relationship. Moreover, environmental policies can be influenced by uncertainties regarding the discount rate and the long time horizon of the decision.

Di Vita (2007) delivers an intuitive explanation for why pollution abatement policies are delayed to later stages of economic development. It is assumed that the marginal return of capital is high at low income levels and decreases at higher income levels. Additionally, a country is only willing to adopt new investments in environmentally friendly projects if the interest rate becomes lower than the discount rate.

2.1.2 Theoretical Underpinnings on Sustainability

The idea of sustainability seeks to explain how human activity can successfully sustain itself and goals without depleting the resources on which it relies. The concept first came to the attention of the public after the 1972 report, “Limits of Growth” prepared by the international think tank; Club of Rome. In 1980, the International Union for Conservation of Nature together with the U.N Environment Programme and World Wildlife

Foundation prepared the World Conservation Strategy to give much credence to sustainability as an international action. Through the 1987 report of the World Commission on Environment and Development (WCED), *Our Common Future*, the term “sustainable development” gained international prominence. Named after its chair, former Norwegian prime minister Gro Harlem Brundtland, the Brundtland Report presented the famous definition of Sustainable development (SD): “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED 1987, 43).

SD has largely been defined by many others (e.g. Tietenberg, 1988) as development that ensures that the income of future generations is no less than that of current generations. The idea of constant natural capital has been held paramount as the criterion for sustainability. Pearce and Turner (1990, p. 44) point out that “the resource stock should be held constant over time.” Robert Repetto (1985, p. 10) proposed that, “at the core of the idea of sustainability, then, is the concept that current decisions should not damage the prospects for maintaining or improving living standards in the future. This implies that our economic systems should be managed so that we live off the dividend of our resources, maintaining and improving the asset base so that the generations that follow will be able to live equally well or better.” For Robert Solow (1991, p. 3), sustainability is simply a matter of distributional equity, about sharing the capacity for well-being between present people and future people.

Despite the agreement on constant consumption over time, thoughts about how to achieve this are different. Turner et al. (1994) explains that while some economists suggest that weak restrictions on the use of natural resources lead towards sustainable development;

others believe strong conditions must be imposed. According to the weak conditions approach, man-made capital can be substituted for natural capital (natural resource stock) without any negative influences for economic production. On the other hand, those in favour of strong conditions argue that as more conversion is made from natural to man-made capital, production will eventually reduce since man-made capital is not a perfect substitute for natural resource capital. They further argue that natural resources or environmental stock have an essential and irreplaceable economic role to play (Daly, 1997; Tisdell, 1997, 1999) and once natural capital is reduced beyond some point relative to man-made capital, future production may fall.

The theoretical papers that first attempted to explain sustainability were in response to the “Limits of Growth” (Dasgupta and Heal ;1974), Stiglitz ;1974), and Solow ;1974). These papers were published following the publication of *The Limits to Growth* (Meadows and others 1972) on the nature of economic growth when a nonrenewable natural resource, as well as (human-made) capital, is a significant input to aggregate production.

In Dasgupta and Heal (1974), later published as (Dasgupta and Heal 1979), the utility discount rate is constant with positive rate of time preference. Therefore, the society’s objective is to maximize present value (PV) of the representative agent’s instantaneous utility using a constant discount rate. They also assumed no technical progress and the resource considered is a fixed nonrenewable stock. Depreciation rate and extraction costs are also ignored.

Their results show that the PV-optimal outcome is bleak for future generations. Utility and consumption initially increases but eventually approach zero in the very long run.

They argued that this result is not due to technical infeasibility of sustained consumption and utility but rather as a result of the direct consequence of a positive utility discount rate, combined with the inherent scarcity of the nonrenewable resource. This causes consumption to be concentrated in earlier years of relative resource abundance, and capital investment is not adequate to offset the effects of resource depletion on output. Clearly, this outcome does not represent sustainable development.

In his model, Stiglitz (1974) assumes that the rate of exogenous technical progress is large enough to offset the effects of resource depletion. This assumption implies that the PV-optimal path can have sustained increases in per capita consumption (even with a growing population, which is omitted from Dasgupta and Heal's model). The results from his model shows that the Cobb–Douglas production function—with isoquants asymptotic to the axes for resource flow and capital services—is inconsistent with minimum energy and material requirements. The same could be said of a sustained exponential rate of technical change. Instead, some ultimate limit to production possibilities would need to be defined in relation to the flow of renewable resources.

Solow (1974) finds that the solution to Dasgupta and Heal's problem is implicitly a moral one. However, Solow's direct focus is on conditions under which constant consumption is feasible. Solow proves that in the circumstances where technical progress do not exist, given the Cobb–Douglas production (and a constant population), constant consumption could be sustained despite declining resource flow by a suitable path of capital accumulation. For this to be achieved (constant consumption), Solow shows that the resource flow must account for less than half the value of production.

Hartwick (1977) and later extensions (Hartwick 1978a, 1978b) expanded the debate by considering the relationship existing between capital investment and constant consumption over time. This is what has come to be known as the Hartwick rule: Under many circumstances in an economy with depletable resources, the rent derived from resource depletion is exactly the level of capital investment that is always needed to achieve constant consumption over time. This rule suggests that for constant consumption to be feasible when the resource is nonrenewable, some kind of unlimited capital resource substitutability is needed, so in recent times, Hartwick's rule has come to be known as a weak sustainability approach. And because capital investment minus resource rents is the net investment in all the economy's productive stocks, the rule also reads as, "Zero net investment forever results in constant consumption forever."

A closed economy divided into three classes of people: workers, capitalists, and nonrenewable resource owners is analysed by Asheim (1986). He shows that Hartwick's rule cannot, then, be decentralized. Resource owners use a rising resource price to offset their diminishing stocks and achieve constant consumption while investing nothing. In contrast, the price facing capitalists (the interest rate) is in fact falling. So, to maintain its consumption, this class has to augment its capital stocks. As a result, capitalists do all the investing, even though their own resource consumption is zero. More generally, resource rents in different parts of the economy need to be invested in proportion to ownership of human-made capital, not in proportion to resource stock ownership.

Asheim neatly moved and extended the closed-economy analysis to different open economies. It was found that the basic Hartwick's rule does not apply to open economies,

because the underlying assumption of “stationary” technology is violated when gains from trade are taken into account.

Krautkraemer (1985) also considers a generalization of the PV optimality problem studied by Dasgupta and Heal (1974), with an environmental disamenity related to cumulative resource use that has the economy generally use less than its entire resource stock. He shows that, depending on society’s discount rate, the initial capital stock and the nature of the disamenity, the economy may converge over time to a “clean” (low-resource-use) or “dirty” (high-resource-use) equilibrium.

In addition, Howarth and Norgaard (1990) has also brought the overlapping generations (OLG) analytical framework to the center of sustainability research. Their study showed that the classic welfare theory results regarding the effect of initial endowments on equity and efficiency readily translate from a static to an intergenerational context. The study also shows that different “endowments” of resource rights (in this case, a nonrenewable resource stock) and labour across two OLGs result in different distributions of wealth, all of them efficient but obviously different in their equity implications. There is no a priori way of saying which is “optimal.”

Howarth and Norgaard (1992) extended their 1990 model to include many generations, capital accumulation, and in place of a nonrenewable resource input to production, an emissions output that accumulates and then causes an external cost of lost production. Their key finding is that the path of consumption across time and the marginal valuation of the environmental externality (measured by the efficient emissions tax) depend on the distribution of wealth across generations (achieved by socially mandated income transfers

from old to young). So, even in theory, there is no fixed notion of “correctly” valuing an environmental cost: The value varies with society’s view of the future, whether expressed as a discount rate or some sustainability criterion.

Using a model with a linear utility function and a constant interest rate Weitzman (1997) shows that when the production possibilities set allows for exogenous technical progress over time (as measured by the “Solow residual” of neoclassical growth theory), the annuity equivalent of consumption will equal Net National Product (NNP) adjusted by a multiplier that reflects in particular “... the pure effect of time alone on enhancement of productive capacity not otherwise attributable to capital accumulation” (p. 7).

Weitzman further suggests that the sustainability of current consumption requires that, it should be no more than its equivalent annuity, as adjusted for the impact of exogenous technical progress. However, this is much more likely to be met if the upward adjustment to NNP from technical progress is much bigger than any possible downward adjustment from including resource depletion and environmental degradation as part of “green” national accounting.

2.2 Empirical Literature

2.2.1 General evidence of the EKC

Over the past decade, there have been proliferation of studies written largely on the EKC to analyze the relationship existing between pollution (environmental degradation) and economic growth and also the validity of the assertion of the EKC.

The first empirical study on the EKC was done by Grossman and Krueger (1995). The study used the Global Environmental Model System (GEMS) dataset for 52 cities in 32 countries during the period 1977-1988 to estimate EKC's for SO₂, dark matter (fine smoke), and Suspended Particulate Matter (SPM) as part of the study of the potential environmental impacts of North American Free Trade Agreement (NAFTA). The GEMS dataset is a panel of ambient measurements from a number of locations in cities around the world. In per capita GDP data in Purchasing Power Parity (PPP), they found turning points at \$4,000-\$5,000 per capita for SO₂ and dark matter while the concentration of suspended particles appeared to decline even at low-income levels. Grossman and Krueger's estimates show increasing levels for all three pollutants for income levels between \$10,000 and \$15,000.

Shafik and Bandyopadhyay's (1992) estimated EKC's for ten (10) different indicators using three different functional forms; log-linear, log quadratic and logarithmic cubic polynomial functional forms. Using a sample that included observations for up to 149 countries during 1960-1990, they found that lack of clean water and sanitation declined uniformly with increasing incomes and overtime. The study also found deforestation to be independent of income levels with river quality worsening with increasing income. In contrast, the air pollutants conform to the EKC hypothesis with turning points at income levels between \$3,000 and \$4,000. Shafik and Bandyopadhyay (1992) finally found that municipal waste and carbon emissions rise with increasing incomes. These results by Shafik and Bandyopadhyay's (1992) were used in the 1992 World Development Report (IBRD, 1992).

Panayotou (1993) also found similar results like that of Grossman and Krueger (1994) and Shafik and Bandyopadhyay (1992) for these pollutants; NO_x (a generic term for mono-nitrogen oxides; nitric oxide and nitrogen dioxide), SO₂ and Suspended Particulate Matter (SPM) using cross section data and a translog specification. The study found turning points at income levels to be around \$3,000 for SO₂ emissions, around \$5,500 for NO_x emissions and around \$4,500 for SPM. He further found deforestation to be conforming to the EKC hypothesis, with a turning point around \$800 per capita concluding that turning point per capita is significantly greater in tropical and in densely populated countries if income distribution is controlled.

Copper and Griffiths (1994) on the other hand, using a panel data for 64 countries over a 30-year period estimated three regional (Africa, Latin America and Asia) EKCs for deforestation only. They obtained a turning point for deforestation in Africa at \$4,760 and \$5,420 for Latin America. These turning points are a multiple of the turning points found by Panayotou (1993) and Shafik and Bandyopadhyay (1992). A cross sectional study by Antle and Heidebrink (1999) found turning points of \$1,200 for national parks and \$2,000 for afforestation. On the other hand, Bhattarai and Hammig (2000) found turning point for deforestation at \$6,800 using a panel data on deforestation for 21 countries in Latin America.

A number of studies also focused on a number of airborne pollutants especially in the mid-1990. Selden and Song (1994) estimated EKC's for four airborne emissions namely SO₂, NO_x, SPM and Carbon monoxide (CO) using longitudinal data on emissions in 30 countries. Of the 30 countries, 22 were categorized as high income, 6 as middle income and 2 as low income. They found turning points to be \$8,702 for SO₂, \$11,217 for NO_x,

\$10,289 for SPM and \$5963 for CO but these turning points were very high in relation to other studies especially the study by Grossman and Krueger (1995). The authors explain the discrepancies in terms of reduction of emission lagging behind reductions in ambient concentrations and as explained by Panayotou (2000), “the use of longitudinal data versus cross-section may help explain part of the difference.

Cole et al. (1997) also estimated income-environment relationships for many environmental indicators including total energy use, transport emissions of SO₂, SPM, NO₂, nitrates in water, traffic volumes, Chlorofluorocarbons (CFC) emissions and methane. They found an inverted U-shaped income-environment relationship only for local air pollutants and CFC’s and concluded that indicators with more global environmental impact either increase with income or have turning points with large standard errors.

Holtz-Eakin and Selden (1995) using a panel data estimated EKC for CO₂ and found that CO₂ emissions per capita do not decline at the early stage until income per capita reaches \$35,000 and this result confirms earlier findings by Shafik (1994).

Nguyen (1999) tested EKC for CO₂ emissions with data from three OECD countries (France, Japan and the US) and three rapidly developing Asian countries (Korea, Thailand and Vietnam). The study results yielded an EKC curve for CO₂ emissions reaching a turning point at \$18,000.

A growing body of work has found that the estimated EKC is sensitive to the sample used and time period. Harbaugh, Levinson, and Wilson (2002) examine the robustness of estimates of the EKC for SO₂. They find that the shape of the curve is sensitive to

changes in the time period chosen and the set of countries included in the study. Copeland and Taylor (2004) have suggested that this may be attributed to a misspecification of the model. He further attributes this to the fact that different sources of growth across countries should yield different reduced-form relations between pollution and income. William Brock and Scott Taylor (2003) has shown that, although all countries may exhibit an EKC relationship, countries are more likely to differ in their turning points and rates of environmental improvement whenever they differ in initial conditions, rate of natural regeneration, etc. It is against this background that this study is to investigate whether or not the possible differences between the sub-regional blocks in SSA will exert any systematic dynamics regarding the relationship between economic growth, trade, FDI and environment.

Authors such as Stern and Common (2001) and List and Gallet (1999) have found no evidence for EKC by using different samples from different sources. While Stern and Common (2001) used data on sulfur emissions in 73 OECD and non-OECD countries over 31 years, List and Gallet (1999) studied sulfur and nitrogen dioxide emissions in about 49 U.S. states over a period of 65 years. Both studies concluded that there is not a common EKC across countries and states respectively.

Aldy (2004) estimated the first EKC analysis of CO₂ emissions in the United States (US). His study used a novel data set of 1960-1999 state-level CO₂ emissions to test the hypothesis that the income-CO₂ relationship reflects changes in the composition of an economy as it develops and the associated role of emissions-intensive trade. The novel data was also used to estimate pre-trade (production-based) CO₂ EKCs and post-trade (consumption-based) CO₂ EKCs. He found that consumption-based EKCs peak at

significantly higher incomes than production-based EKC, implying that emissions-intensive trade drives at least in part the income-emissions relationship. The study further investigated the robustness of the estimated income-CO₂ relationship through a variety of specifications and concluded that the estimated EKCs appear to vary by state and the estimated income-emissions relationship could be spurious for some states with nonstationarity income and emissions data.

Roca and Alcantara (2001), in examining the relationship between growth and CO₂ emissions rejected the existence of the EKC in Spain from 1972 to 1997. Akbostance et al. (2009) using time series CO₂ emissions 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 inverted U-shaped relationship between pollutants (waste gas, waste water and solid waste) and economic growth from 1985 to 2005 in China. He and Richard (2010) found little evidence in favour of the EKC hypothesis in Canada for CO₂ emissions. . 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.

Giovanis (2013) using micro data from Britain investigated the relationship between air pollutants (O₃, SO₂ and NO_x), 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.

In SSA, a number of studies have been conducted about the existence of the inverted U shaped income-environment relationship for at least some few pollutants. Omojolaibi

(2010) tested the EKC hypothesis for CO₂ using a panel data methodology to estimate the relationship between carbon emission and GDP in Ghana, Nigeria and Sierra Leone over the period of 1970-2006. The study found that, the pooled ordinary least squares (OLS) satisfied the EKC hypothesis whereas the fixed effects (FE) results contradicted the EKC hypothesis in West Africa.

Omisakin (2009) investigated the EKC hypothesis for CO₂ with annual data of CO₂ per capita and GDP per capita from 1970-2005. The study found no long run relationship between carbon emissions per capita and income per capita in Nigeria. The study results on the other hand depicted a U shaped income-environment relationship rather than an inverted U shaped contradicting the EKC hypothesis.

Bello and Abimbola (2010) concluded the non-existence of the inverted U shaped income-environment relationship in Nigeria confirming earlier studies by Olusegun (2009). Using a time series data from 1980-2008 on Nigeria, the study concluded that carbon emission in Nigeria is not driven by economic growth but rather driven by financial developments such as foreign direct investment (FDI). This is because the study found economic development not to have any influence on CO₂ emissions in Nigeria.

Fodha et al. (2010) also investigated the relationship between economic growth and the environmental degradation for a small developing country, Tunisia. The study used a time series data from the period 1961-2004 with CO₂ and SO₂ as the environmental indicators and GDP as the economic indicator. The study results showed that there is a long run cointegrating relationship between per capita GDP and the per capita emissions of the two pollutants (CO₂ and SO₂) but the relationship between CO₂ emissions and

GDP was found to be more monotonically increasing as compared to that between SO₂ and GDP. The study further tested the causal relationship between income and pollution and found that, the relationship between the two in Tunisia is unidirectional both in the short and long run implying that, income causes environmental damages and not vice versa.

2.2.2 Various hypotheses for EKC

An area that has received very little attention in the literature is the evaluation of the various hypotheses for the EKC. Given the proliferation of studies using the EKC, those that aimed at examining how the interaction between different sources of growth interact with income and other effects to determine the relation between growth and pollution is very scanty.

It has been argued by Copeland and Taylor (2004) that, “Unless we can clarify the causal mechanisms involved, the work will be of little use in helping us understand how growth or trade affect the environment.”

This aspect of the debate has been explored by some few studies such as Hilton and Levinson (1988) and Gawande et al. (2000). In examining the link between lead emissions and income per capita, Hilton and Livinson (1988) used a panel of 48 countries over 20 years. The study divides the changes in pollution into two different components (scale and technique effects). Their study is the first to provide direct evidence on two distinct processes (scale and technique effects) that together result in an EKC. The study

found that, while the technique effect produces a negative monotonic relationship between lead content per gallon of gasoline and income per capita, the scale effect links greater gasoline use to greater income.

The study by Gawande et al. (2000) estimated an EKC for hazardous waste sites in the United States and find evidence that the number of hazardous waste sites in a region increases the net out-migration rate but only after a threshold of income is reached, which is consistent with an income effect driving the downward portion of the EKC. They further argue that due to huge cost involved in cleaning up hazardous waste sites, the income effect would be reflected in net out-migration rates. Again, the number of hazardous waste sites in the region increases the net out-migration rate only after a threshold of income is arrived, which confirms that an income effect drives the downward portion of the EKC.

Furthermore, by re-examining one year of sulfur dioxide data drawn from Grossman and Krueger's (1993) study, an attempt to assess the importance of the composition effect in predicting cross country differences in pollution levels has been carried out by Gale and Mendez (1998). The study regressed concentrations of pollution on factor endowment data from a cross-section of countries together with income based measures designed to capture scale and technique effects. Incomes per capita were controlled by accounting for differences in cross-country levels that may determine pollution supply. Their result suggests a strong link between factor endowments and pollution even after controlling for per capita incomes. This means that other national characteristics can contribute to pollution outcomes (Stern; 2004).

Other studies have tried to assess the relative importance of technique, scale and composition effects in accounting for changes in pollution. Emissions of six air pollutants in the United States over 20 years were compared by Forest and Lockhart (1999). The observed changes in pollution were decomposed into changes in scale, composition of economic activity and changes in emissions per unit of output. The study examined the relative strength of the three effects and finds that the technique effects were profound in explaining the fall in emissions. The presence of the composition effects were however not strong enough to account for the fall in total emissions during the period.

In a related study, Hettige, et al. (2000) used panel data on industrial water pollution from 12 countries. The study attempted to isolate the composition and technique effects and how they change with income. They decomposed pollution into the manufacturing pollution intensity, the share of manufacturing in the economy, and total output. They then separately regressed firm level pollution intensities, the average pollution intensity in manufacturing, and the manufacturing share on per capita income. Their results showed that the composition effect is small in magnitude compared to that of scale effects. Also, the income elasticity of pollution intensity was estimated at about -1 implying a strong technique effect.

2.2.3 International trade and the Income-environment relationship

Over the last few decades, both environmentalists and those in trade policy realm have engaged in heated debates concerning the environmental consequences of international

trade. This has been necessitated by concerns over global warming, species extinction and industrial pollution (Copeland and Taylor; 2004).

It has clearly been established that whereas trade liberalization changes relative goods prices by opening up the economy to increased foreign competition, growth increases endowments or improves technology at given external prices. However, empirical evidence has also shown that trade liberalization also facilitates economic growth, and at a theoretical level, trade can influence the rate of growth if it brings about innovation or factor accumulation. (Gene Grossman and Elhanan Helpman; 1991).

Antweiler et al., 2001 has stated that the effect of globalization or policy that supports trade to carbon emission is very dependent on a country's economic structure. Given that this statement is true then on the basis of scale effect, globalization policies that seek to expand market access will have negative impact on CO₂ content in the air. This translate to the fact that efforts to increase production in order to increase production surplus and or increase balance of trade surplus that will eventually have positive impact on national income must be paid expensively by low environmental quality. Using panel data from 1970 to 2000 covering 119 countries McCarney and Adamowicz (2006) supports the above statement.

On the contrary, Ederington and Minier (2003) rejected the argument that trade flows have negative impact on the environment. They argue that the treatment of environmental variable in a model whether as endogenous or exogenous variable will affect the casualty relationship between trade and carbon emissions.

Shafik and Bandyopadhyay (1992) in their EKC formulation included a trade intensity variable defined as the ratio of (exports + imports) to GDP as well as the Dollar's index of openness (which reflects the extent of price distortion in the economy). Using OECD country data, the study tested the hypothesis that the more open an economy is, the cleaner the production methods it employs. The study found weak evidence that economies that are more open tend to pollute less.

In formulating their EKC, Groosman and Kreuger (1993) used the same measure of trade openness (ratio of sum of exports and imports to GDP) as that of Shafik and Bandyopadhyay (1992). Employing the Global Environmental Model System (GEMS) data set for 52 cities in 32 countries during the period 1977-1988, the study carried out a hypothesis testing to test whether greater openness to trade would lead to lower environmental standards in an effort to preserve competitiveness in the face of international competition. The study found the relationship between pollution and trade to be insignificant. However, in the case of urban concentrations of SO₂, it was found that trade actually reduces pollution levels.

Copeland and Taylor (1994) revealed in their study that trade openness reduces the pollution level in industrialized countries (mostly OECD countries) but increases the pollution level in most developing countries, thereby increasing the world's pollution level. The study employs a simple, two-country static model of North-South trade to examine analytically the relationship between income, pollution and international trade. In addition, the study found that, asymmetric growth that favours the wealthy North widens the gap in pre-trade and post-trade factor prices, resulting in composition effects that increase world population.

Using pooled cross-country and time series data on commercial energy consumption to quantify the impact of the actual movement of goods between countries, Suri and Chapman (1998) found that industrialized countries in exporting manufactured goods have increased their energy consumption contributing to the upward sloping portion of the EKC. The study argues that, industrialized countries in importing manufactured goods have reduced their energy consumption contributing to the downward sloping portion of the EKC. The study further asserts that, a 10% increase in the ratio of imports of all manufactured goods to domestic production of all manufacturers has been associated with a 1.3-1.7% reduction in energy in industrialized countries. Suri and Chapman (1998) also found that adding trade variables explicitly into EKC models raises the turning points for energy consumption and energy related emissions from 55,000 to 224,000, in which both values are far outside the sample range.

Using a time series data for the period of 1960-2009 for Japan, Hossain (2012) examined the dynamic causal relationship between carbon dioxide emissions, energy consumption, economic growth, foreign trade and urbanization. The study found short run unidirectional causalities from trade openness to CO₂ emissions and also from trade openness to energy consumption. The study concluded that environmental quality is found to be a normal good in the long run with respect to trade openness.

In testing the existence or otherwise of the EKC hypothesis for China over the period 1975-2005 Mahmud and Jalil (2009) examined the long run relationship between carbon emissions and explanatory variables such as energy consumption, income and foreign trade by using the ARDL Bounds testing approach. The study found foreign trade to be

positively related to carbon emissions although the coefficient of foreign trade was statistically insignificant. The study used openness ratio as a proxy for foreign trade.

Using the same methodology as Mahmud and Jalil (2009), Shahbaz et al. (2012) included trade openness into its regression equation to examine the relationship between energy consumption, financial development, trade openness and CO₂ emissions for Indonesia over the period of 1975Q1-2011Q4. The study found a long run relationship was found between trade openness (exports+ imports) and CO₂ emissions and concludes that trade openness plays a role in improving environmental quality.

2.2.4 Foreign direct investment (FDI) and the income-environment relationship

Other studies have also included financial development indicators to help address the relationship between environmental degradation and economic growth. They argue that, financial development play a deterministic role in environmental performance. Even though there is still limited empirical evidence on the channels of financial development and environmental performance, the few studies that have been done conclude that financial sector development matters for environmental performance.

Baek and Koo (2009) estimated the relationship between FDI and carbon emissions for China and India, two countries with relatively high economic growth. In both the short and long run, existence of multinational corporations in China has negative contribution to the environmental quality. They further discovered that the weak regulation in environmental field has contributed to the increased carbon content in the air. In the case of India, the short run analysis showed no casualty relationship. An attempt to explore

this issue in China was done by Cole et al., (2011). They proposed a hypothesis that the FDI country of origin also affects this casualty relationship. Using panel data for four years in 112 cities in China, they noticed that foreign -owned companies that are not associated with China (Taiwan and Hong Kong) mostly invest in petroleum, gas and sulphur dioxide industries that produce relatively high pollutants.

Granger causality has been tested by Hoffman et al. (2005) between FDI, measured by the net inflow of foreign direct investment (\$US) and pollution, proxied by CO₂ emissions from industrial processes including emission from solid, liquid, gas fuels and gas flaring. The study used an unbalanced data comprising of 112 countries with a time length varying between 15 to 28 years and found out that CO₂ level granger cause inward FDI flows in low-income countries. On the other hand, inward FDI flows granger causes CO₂ levels in middle- income countries. No granger causality was found in high-income countries.

Jalil and Feridun (2011) found financial development measured as the ratio of liquid liabilities to GDP, to be negatively related to environmental degradation in China. Employing the Autoregressive Distributed Lag (ARDL) bounds testing procedure and using a time series data from 1953 to 2006 with the objective of examining the impact of financial development, economic growth and energy consumption on environmental pollution, financial development was found to be a major contributor to the decline in environmental pollution.

Tamazian et al. (2009) used standard reduced-form modeling approach to investigate the linkage between economic development and environmental quality. The study went

further to investigate the linkage between economic development and financial development. Using a panel data for the BRIC countries (Brazil, Russia, India, China) over the period 1992-2004 and controlling for country-specific unobserved heterogeneity, the study found that both economic and financial development are determinants of environmental quality in BRIC economies. The study argues that higher degree of economic and financial development reduces the environmental degradation and as a result suggests that financial liberalization and openness are essential factors for the CO₂ emissions reduction. The study further suggests the adoption of policies directed to financial openness and liberalization with the aim of attracting higher levels of research and development.

The linkages among economic growth, energy consumption, financial development, trade openness and CO₂ emissions over the period of 1975Q1-2011Q4 in Indonesia was examined by Shahbaz et al. (2012) by using the Zivot-Andrews structural and break unit root test and the ARDL Bounds testing approach to cointegration. Using real domestic credit to private sector per capita as a proxy for financial development, the study found a positive long run relationship between financial development and CO₂ emissions. Financial development was concluded to contribute in reducing pollution.

Liang (2006) found a negative correlation between FDI and air pollution, suggesting that the overall effect of FDI may be beneficial to the environment. Liang's finding further suggests the argument that FDI in developing countries are more likely to act as a conditional factor for advanced and cleaner environmental technologies. Xing and Kolstad (2002) on the other hand assert that, there exist a positive correlation between the

amount of sulfur emissions in a host country and inflows of US FDI in heavily polluting industries.

A much recent study by Mizan and Halimaliton (2012) concluded that higher degree of economic and financial development reduces environmental quality. Using a non-linear model and data from secondary sources such as the Air Quality Data Report and the Malaysia Environment Quality Report to estimate the relationship between FDI and environmental degradation, Mizan and Halimaliton (2012) found FDI to be positively related to CO₂ emissions. They found FDI to be a significant determinant of CO₂ emissions and assert that, a 1% increase in FDI leads to a rise in CO₂ emissions by 2.03%. They conclude that environmental quality in Malaysia becomes worse with the development of FDI.

In sub Saharan Africa, Abimbola et al. (2010) has explored the linkages between some financial development indicators and environmental degradation. Using a time series data from 1980-2008 in Nigeria, the study investigated the relationship between economic growth and environmental quality. Results from the study indicated that the carbon emissions in Nigeria are influenced by financial developments and not necessarily driven by economic growth; as the study found a statistically significant negative impact of FDI stock on per capita CO₂ in Nigeria during 1980-2008.

2.2.5 The Pollution Heaven Hypothesis (PHH) and The EKC

Trade has been considered as one of the most important causes of the EKC. Developed countries with strict regulations are most likely to shift their production of dirty products

to developing countries with weaker environmental standards. This phenomenon has commonly been described as the pollution heaven hypothesis (PHH). Evidence on the assertion of the PHH have produced mixed findings and till now have been inconclusive. Whereas some studies support its existence others have not found any evidence for its support.

Using 2,889 manufacturing equity joints venture projects in China from 1993 to 1996; Dean (2009) found evidence supporting the PHH by foreign investors in China but not from investors from high income countries. Also, Mani and Wheeler (1997) using data from 1960 to 1995 between OECD (particularly Japan) and developing economies (Asia and Latin America) found evidence for the PHH.

Cave and Blomquist (2008) in their study found evidence for PHH with EU energy intensive trade but found no evidence supporting toxic intensive trade with poorer OECD economies and non- EU European countries from 1970 to 1999. Jie He (2006) studied the PHH using 29 provinces in China and found out that a 1% increase in FDI led to 0.098% increase in pollution (SO₂). Cole (2004) found little evidence for the PHH using four developed and developing trade pairs namely; USA-Asia, USA-Latin America, UK-Asia and Japan-Asia between 1977 and 1995.

Eskeland and Harrison (2003) in testing the authenticity of the PHH for four developing countries ((Mexico (1990), Venezuela (1983-1988), Morocco (1985-1990) and Cote d'Ivoire (1977-1987)) and USA (as the developed country) found no strong evidence for the PHH.

Letchumanan and Kodama (2000) in testing the validity of the PHH between developing (Malaysia, Singapore, Thailand, The Philippines) and developed countries (USA, Germany, Japan) between 1978 and 1995 suggested that there is no strong empirical validation for the PHH. Instead they argued that trade and investment do lead to the movement of high technology and cleaner products and processes to developing countries which help them to improve upon their technology and also produce environmental responsive products.

Kaika and Zervas (2013) has argued that the import of pollution-intensive goods in developed countries can explain the downward sloping part of the EKC while the exports of those goods explains the upward sloping part in developing countries. According to Cole (2004), if the pollution havens exist, they are likely to be temporary and limited to certain sectors and regions.

Others such as Agarwal (2012) have analyzed the joint impact of FDI and trade liberalization policies on environment. The study introduced explicitly and jointly the two major elements of globalization namely trade liberalization and the inflow of FDI into the analysis. Annual data from 1980 to 2008 for Malaysia from the World Bank data base was used. To start with, the paper explored the causal relationship between FDI, trade, and Gross Domestic Product (GDP) growth. Also variables were tested for the degree of stationarity and co integration. The Autoregressive Distributed Lag (ARDL) approach to co-integration techniques was employed to capture the impact of short-run dynamics and long-run equilibrium. The study finds that economic liberalization policies have been helpful for the growth of the Economy. The growth environment nexus via the Environment Kuznet Curve Hypothesis (EKC) for Malaysia is confirmed by the study.

Further, the results do not suggest that trade liberalization policies have directly affected environment. Pollution Heaven hypothesis is also not fully supported by the data.

2.2.6 The Environmental Kuznets Curve and Sustainability.

Despite the huge diffusion of EKC studies, this model has been criticised for incompleteness of a sustainable development analysis. At this purpose, some contributions have attempted to investigate the theoretical implications of sustainability and the possible linkages with the empirical EKC formulation. The role of sustainability (and not only environmental degradation), the implications related to technical progress, and the statistical techniques based on panel data (and not pure cross-section analyses) represent the main steps ahead recently made by the scientific community (Farhani et al.,2014).

The study by Munasinghe (1999) is one of early studies that tried to explore the linkages between sustainability and EKC. His study employed the Environmentally Adjusted Net Domestic Product (EDP), calculated by subtracting to the Net Domestic Product the economic value of the net loss of natural capital. The corresponding EKC from the study showed a steeper upward sloping curve and can be replaced from a reversed-C relation if, beyond a threshold level of environmental degradation, EDP begins to decline. In this case, it should be considered that EDP doesn't indicate if the saving rate is high enough to guarantee a future income level equal to the current one.

Computing an indicator like the Genuine Saving (GS) provided by the World Bank (Hamilton, 2000), makes it possible to have a real saving rate net from the amounts

needed to cover the depletion of natural resources and the economic value of social cost linked to pollution damage. While trends in national income per capita (using traditional or green measures) may express the effect of economic growth in the short run, measuring trends in real savings per capita could give a clearer picture of the influence of wealth creation on environmental quality.

In this regard, some studies have also factored the issue of sustainability by building a Modified EKC (MEKC) in order to consider a wider concept of development rather than pure economic growth, including well-being aspects and sustainability of the development process.

Using a macroeconomic measure of sustainability such as the World Bank's Genuine Saving and a measure of well-being such as the United Nations' Human Development Index, Costantini and Martini (2006) formulated a model in order to analyse linkages between higher welfare levels and natural resources consumption, verifying the sustainability of human development. In order to represent a more general framework geared towards sustainable development, the dependent variable defined as environmental degradation in the standard EKC is replaced by a macroeconomic sustainability indicator based on the Genuine Saving (GS) index provided by the World Bank in the World Development Report (World Bank, various years).

The study employed a panel analysis for three years (1990-1995-2000) for a wide range of countries (including developed and developing countries) in order to respond to criticisms related to conjunctural results linked to pure cross-section studies.

In order to reduce dissimilarities between a standard EKC and a modified EKC, the GS was taken only in the components related to environmental degradation and depletion, hence accounting for a strong sustainability criterion. Furthermore, the income per capita as the driving factor of the U-shaped curve was substituted with a broad definition of development based on the UNDP methodology of Human Development.

Following recent EKC studies, the role of institutions was analysed, but differently from other contributions it was modelled as an endogenous variable. Finally, the role of technological progress was introduced and modelled both as creation and diffusion of technology.

By comparing the turning points of the MEKC and EKC, the results of the study confirms that the threshold level of human development in the MEKC corresponds to an income per capita level lower than the threshold level for the EKC, confirming the possibility of “tunnelling through the curve” as suggested in Munasinghe (1999). The results show that human development should be the first objective of international development policies, and an increase in human well-being is necessary to provide a sustainability path.

Costantini and Monni (2006) test the hypothesis of a system of equations representing the possible interrelations between the EKC and the so-called Resource Curse Hypothesis, trying to highlight which variables play a key role in a long-run sustainable development path, in the presence of large exhaustible resources stocks. The study attempted to analyse the casual relationships between economic growth, human development and sustainability by combining the Resource Curse Hypothesis (RCH) and EKC models and adopting a human development perspective.

In their model, they attempted to substitute the income factor of the EKC with a more capability oriented measure such as the HDI. In order to represent a more general framework geared towards a sustainable development, the pollution – related dependant variable is replaced by a macroeconomic sustainable indicator such as genuine savings (GS). In line with classic EKC, the study includes other control variables such as trade flows and manufactures as the share of value added. This allowed for analysis of the effects of economic globalization on sustainable development.

The results of the study was in line with the traditional EKC studies – achieving an adequate sustainability level with a positive capital accumulation process is a necessary condition for such an objective and environmental protection is considered a secondary (or luxury) good. More specifically, GS is observed to increase as long as HDI augments and almost null GS variation rates are connected to countries with low and medium – low levels of HDI. In this case, the threshold level of un-sustainability is associated to a low-medium level of HDI (around 0.60), while threshold levels for classical EKCs are well above this value, hence confirming the so-called “tunneling through the curve” hypothesis formulated by Munasinghe (1999). The concept proposes that developing countries could learn from the experiences of industrialized nations, and restructure growth and development to address potentially irreversible environmental damages from an early stage and thereby ‘tunnel’ through any prospective EKC. Finally, the results showed that there is no specific sign that the globalization process could bring negative effects to developing countries.

In a much recent study, Farhani et al. (2014) has explored the issue further by parallelly examining two models. The first one is based on the traditional EKC literature, which

includes CO₂ emissions per capita, per capita real GDP, energy consumption per capita, trade openness, manufacture value added and modified HDI that does not include GDP. The second model is based on the concept of modified EKC literature was shown in order to relate negative GS per capita, HDI, energy consumption per capita, trade openness, manufacture value added and the rule of law as one important dimension of governance in the control of corruption. To achieve the main goal of this study, the panel models were likewise established using 10 Middle East and North African (MENA) countries over the period 1990–2010.

With respect to MEKC, in the long-run the elasticity of negative GS per capita with respect to the HDI is 1.995–2.024HDI; a 1% increase in energy consumption per capita increases negative Genuine Saving per capita by approximately 1.153%; a 1% increase in trade openness increases negative Genuine Saving per capita by approximately 0.252%; a 1% increase in manufacture value added increases negative Genuine Saving (GS) per capita by approximately 0.066%; and a 1% increase in the rule of law decreases negative Genuine Saving per capita by approximately 0.019%.

Jha and Murthy (2003) represent a relevant contribution useful in order to solve the problem of non- univocity of results. Their study emphasized the role played by the level of global environmental degradation (GED) in economic development; this link has been ignored in the existing literature on the environmental Kuznets curve (EKC). They developed a composite environmental degradation index (EDI) using Principal Components Analysis (PCA) and related it to an appropriate measure of economic development, i.e., the human development index (HDI), with a view toward developing a global EKC(GEKC) for 174 countries. The 174 countries examined are divided in three

classes of HDI (high, intermediate and low, respectively with $HDI > 0.8$, $0.8 < HDI < 0.5$, $HDI < 0.5$) and the regression output indicates a positive correlation between EDI and HDI for countries with high HDI, a negative relation for countries with low HDI and weakly negative relation for the intermediate class. These findings confirm an inverted U-shaped relationship, where the level of environmental degradation is strictly dependent on the development stage.

In their study, Abdulia and Ramsecke (2009) analyzed the effect of trade liberalization on sustainable development within the framework of the Environmental Kuznets Curve (EKC), using a cross-section of countries over the period 1990-2003. This paper explores the interrelations between economic growth, international trade and environmental degradation both theoretically and empirically. . Several environmental factors and one sustainability indicator are analyzed for the full sample, regions and income groups.

Separate analyses were conducted for low-income and high-income groups, as well as regional groups. In line with other studies, the study employed adjusted net saving (ANS) sourced from the World Bank's World Development Indicators. As in Costantini and Martin (2007), the specification with ANS as the dependent variable employs lagged income variable as the explanatory variable. This is due to the fact that ANS is measured as a percentage of GNI, as such using current income could result in biased estimates.

The empirical results appear to support the notion that no unique relationship exist between economic growth, trade and the environment across all countries and pollutants. The income coefficients indicate that there is an EKC for most environmental indicators, but with several reservations. First, in all cases the turning points are higher than the

mean income. As a result, there is a quasi-monotonic increasing relationship for energy consumption and a long way to reach the turning point for most countries for the other variables. Second, for energy consumption there is a strictly increasing relationship for low income countries.

In addition, none of the various theoretical hypotheses that consider the link between trade and the environment can be fully confirmed. If anything, there is support for the PHH in the income group regressions. The empirical results from the study and those of previous studies suggest that many poor regions of the world are failing to be on a sustainable path, although this is particularly important for developing countries, which are the most exposed and vulnerable to the health and productivity losses associated with a degraded environment. Specifically, the estimates from the Adjusted Net Savings measure indicates that trade liberalization might be beneficial for rich, but harmful for poor countries' sustainable development efforts.

Samimi et al. (2011) have also estimated and evaluated the relationship between environmental sustainability index and economic growth in developing countries during 2001-2005. The Environmental Sustainability Index (ESI) is a composite index that tracks a diverse set of socio-economic, environmental, and institutional indicators that characterize and influence environmental sustainability at the national scale. It was launched in 1999 by Professor Esty, director of the Yale Center for Environmental Law & Policy, in cooperation with Columbia University's Center for International Earth Science Information Network (CIESIN) and the World Economic Forum's Global Leaders for Tomorrow Environment Task Force. The Environmental Sustainability Index (ESI) provides a gauge of a society's natural resource endowments and environmental

history, pollution stocks and flows, and resource extraction rates as well as institutional mechanisms and abilities to change future pollution and resource use trajectories.

The index varies between zero to 100 in such a way that a higher index means a better Environmental Sustainability. This index which is opposite of the environmental deterioration index was used in the study and therefore expect a u- shaped Kuznets Curve in order to support Kuznets hypothesis.

Specifically the study regressed Environmental Sustainability Index (ESI) on Gross Domestic Product (GDP) per capita, GDP per capita squared, trade openness [measured as ratio of trade (imports + exports) to GDP], industrialization [measured as Industry value added (% of GDP)] and Government Size that is represented by the share of government consumption in GDP.

In accordance to theoretical priors, the results revealed that the coefficient of GDP per capita is positive and statistically significant and the coefficient of GDP per capita squared is negative and significant. Based on these coefficients, there is an inverted-U curve regarding the relationship between environmental sustainability and economic growth. Thus, the results don't support the Environmental Kuznets Curve (EKC) hypothesis. Also, they found that the coefficient of openness is positive and significant. Industrialization and government size are negative but industrialization is insignificant.

Following similar approach as Samimi et.al. (2011), Hyun-Hoon Lee et al. (2005) have also examined the effect of income on environmental sustainability, after controlling for population density and civil-political liberty. The study employed the 2005 Environmental Sustainability Index (ESI) produced by the Yale Center for Environmental

Law and Policy at Yale University, in collaboration with the Center for International Earth Science Information Network at Columbia University as the indicator for sustainability.

Because the study was interested in examining how different pollution measures and eco-efficiency (a management concept that encourages firms to search for environmental improvements that yield parallel economic benefits) measures of environmental sustainability are related with income, the authors selected among the 21 indicators (in the ESI) only those indicators which fall into either of these two categories. In this light, they selected 2 indicators for pollution measures and 9 indicators for more eco-efficiency related measures of environmental sustainability. Thus, 10 indicators in the 2005 ESI report are excluded from this study. They are excluded because they are social-issue related, uncontrollable natural disaster related, too broad a measure of political and governance system, or too broad a measure of technology.

Income per capita was the main explanatory variable of interest of the study. Because the study was not interested in measuring the precise shape of the EKC but in the general relationship between income and various measures of environmental sustainability, the study used the natural logarithm of per capita GDP as a key explanatory variable but does not include the squared value of the log of per capita GDP. Among the 146 countries in the 2005 ESI report, they were able to obtain per capita GDP of 2003 for 140 countries.

In addition, two control variables were included on the right hand side. The first variable is the log of land area per capita with the Land area (in sq km) sourced from the CIA's website (<http://www.cia.org>). This is included because higher population tends to lead to

environmental degradation (for a given level of per capita income). The second variable; Civil and Political Liberties (CIVLIB) as a measure of civil and political freedom is drawn from the 2005 ESI report. The motivation for this is based on the fact that many studies (for example, Barrett and Graddy, 2000) has revealed that an increase in civil and political freedoms significantly reduces some measures of pollution and hence improves the quality of the environment. To control the collinearity between income and the civil-political liberty index, the study employed an income adjusted civil-political liberty index defined as the residual from a regression of the original civil-liberty index on log of per capita income and constant.

Lastly, a dummy variable called ASIA-PACIFIC which takes 1 for the 32 countries in the Asian and Pacific region and 0 otherwise was included in the study. This was done to investigate how the countries in the Asian and Pacific region perform in comparison with countries in other regions.

The regression results for the overall measure of environmental sustainability revealed that the estimated effect of per capita GDP on the ESI is positive and statistically significant at the one percent level. The same is true of land area per capita and civil-political liberty index. The estimated coefficient for the Asia-Pacific dummy has a negative sign, but is not statistically significant. Thus, one may conclude that a country's environmental sustainability improves as the country's income per capita improves, population density declines and/or the country enjoys greater degree of civil and political liberty.

In conclusion, the study revealed that while income appears to have a beneficial effect on pollution measures, it has a detrimental effect on most eco-efficiency measures of environmental sustainability, *ceteris paribus*. The study further suggests that the Environmental Kuznets Curve needs to be renamed as the “Pollution” Kuznets Curve in order to give correct impression that not all environmental measures but only pollution measures may improve with income. This also suggests that while conventional policies focus more on pollution control, they need to be combined with policy options focusing on eco- efficiency aspects of environmental sustainability in the process of economic development. Otherwise, economic growth will continue to degrade environmental sustainability in most countries. It has also been found that low population density and civil-political liberty have been identified as important in their effects on environmental sustainability, but the signs for the estimated coefficients are not always positive. This is especially apparent for civil and political liberty. Thus, there is evidence that civil and political liberty does not automatically improve environmental sustainability.

2.3 Concluding Remarks

From this chapter, it has been revealed that, while some empirical studies provide evidence for an EKC relationship between economic growth and the environment (both quality and sustainability), there is still no conclusive proof regarding the existence or the non-existence of the EKC as others also show evidence of a positive monotonic and a U-shaped relationship. Similar observations can be made from the empirical studies on the trade, FDI and environment relationships. Whereas some reports a positive relationship,

others show a deteriorating effect on the environment. It can also be observed that most of these empirical studies have been conducted in the developed economies with a few conducted in developing countries or regions like SSA. In addition, most of the empirical studies only concentrated on environmental pollution with only a handful dedicated to sustainability. In view of this, the study tends to fill these gaps by providing new evidence on the effects of economic growth, trade and FDI on the environment in SSA by considering indicators on both pollution and sustainability.



CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter discusses in detail the theoretical framework and statistical techniques or approaches employed in addressing the various objectives of this study. As already revealed in the literature review of this study, different methodologies, sources and forms of data have been used to address the environmental effects of economic growth, trade and FDI through the EKC framework. This chapter has six (6) sections. The next section discusses the conceptual framework, followed by a discussion on the variables used and data sources. Section 4.4 focuses on the most plausible econometric estimation technique, followed by a discussion on some diagnostic tests on the model used. The last section is on the conclusion of the chapter.

3.1 Conceptual Framework

The studies on the relationship between environmental effects and growth have been done using two possible approaches to model construction. The first is to model the structural equations by relating environmental regulation, technology, and industrial composition to environmental quality. The other deals with estimating a reduced-form equation that seeks to relate the state of the environment to the level of income. Fundamentally, Dinda (2004) has argued that the reduced-form model denies any insight into the underlying causes of EKCs, thereby making it difficult to design specific policy

implications from EKC. In this light, the structural form of modeling is held superior to the reduced-form model.

Due to the difficulty and insufficiency of data on environmental regulation and the state of the existing technology, this study will adopt the reduced-form approach following what has been spelled out in the literature on this subject by adding appropriate variables in accordance with analytical interests.

In addition to the above arguments the study will adopt a dynamic panel model. It has been pointed out by Halkos (2003) that the use of a static model could be justified only if the processes were very rapid or if the static equation represented an equilibrium relationship and that since neither a rapid adjustment nor equilibrium relationship between pollution and income were expected in the observed data, a dynamic model approach would provide more statistically sound estimates.

Following the work of Taguchi (2012), and in line with the argument of Halkos (2003), a dynamic panel model is constructed by inserting a lagged dependent variable as a regressor into the EKC equation for materializing a partial adjustment towards an equilibrium emissions level.

Based on analytical interests argued above, the modified EKC framework is specified as follows:

$$\text{Environmental quality} = f [\text{economic growth (Y), economic growth squared (Y}^2\text{), Foreign Direct Investment (FDI), trade openness (TOP), Total Population (POP)]$$

(3.1)

3.2 Empirical Estimation

In order to analyse the environmental effects of trade, FDI and economic growth, a dynamic panel regression model is estimated based on the reduced form model of the EKC framework introduced by Halkos (2003).

The study adopts the dynamic panel growth framework in order to account for temporal autocorrelation, reduce the level of potential spurious regression which may lead to inaccurate inferences and inconsistent estimates. It also includes the lagged dependent variable as a regressor in order to capture the lagged effects (persistence) of the dependent variable.

The dynamic panel growth model is specified as:

$$y_{it} = \alpha y_{i,t-1} + x'_{it} \beta + \varepsilon_{it} \quad (3.2)$$

Where,

$$\varepsilon_{it} = \mu_i + v_{it}$$

That is, the error term in equation (3.2) is decomposed into two components with the first component measuring the unobserved country-specific effects while the second component is the idiosyncratic error term.

Equation (3.2) can therefore be re-written as:

$$y_{it} = \alpha y_{i,t-1} + x'_{it} \beta + \mu_i + v_{it}$$

Where i indexes the countries under study, t denotes the years, y_{it} is the proxy for environmental quality, $y_{i,t-1}$ is the lagged proxy for environmental quality, x'_{it} is a matrix of all the explanatory variables including trade and FDI, μ_i is an unobserved country-specific time-invariant effect, and v_{it} is the idiosyncratic error term.

From the dynamic panel equation (3.2) and following Taguchi (2012); Halkos(2003); and Kleemann et al. (2009) with few modifications based on the description of the variables and analytical interests, the model to be estimated is therefore written as:

$$EQ_{it} = \alpha_1 + \alpha_2 EQ_{it-1} + \alpha_3 (GDP/P)_{it} + \alpha_4 (GDP/P)_{it}^2 + \alpha_5 FDI_{it} + \alpha_6 TOP_{it} + \alpha_7 POP_{it} + \alpha_8 \sum_1^4 D_i + \alpha_9 \sum_1^4 (GDP/P)_{it} * D_i + \alpha_{10} \sum_i^4 (GDP/P)_{it}^2 * D_i + v_{it} \quad (3.3)$$

Where,

EQ represents environmental quality variables of environmental degradation measured by CO2 emissions per capita (CO2/P) and environmental sustainability represented by Adjusted Net Savings per capita (ANS/P).

POP_{it} denotes Total Population.

(GDP/P)_{it} denotes Income per capita.

(GDP/P)_{it}² denotes the square of Income per capita.

FDI_{it} denotes Foreign Direct Investments.

TOP_{it} denotes Trade Openness.

D_i = Regional dummy for four regional blocks (East, Central, Southern and West Africa sub-regions).

$(GDP/P)_{it} * D_i$ = Product (interaction) of GDP per capita and the regional dummies.

V_{it} = Idiosyncratic error term.

The index i represents the countries and t indexes the time period in years.

If $\alpha_3 > 0$ and $\alpha_4 = 0$, it reveals a monotonically increasing linear relationship indicating that rising incomes are associated with rising levels of emissions.

If $\alpha_3 < 0$ and $\alpha_4 = 0$, it reveals a monotonically decreasing linear relationship indicating that rising incomes are associated with falling levels of emissions.

If $\alpha_3 < 0$ and $\alpha_4 > 0$, it reveals a U-shaped relationship.

If $\alpha_3 > 0$ and $\alpha_4 < 0$, it reveals an inverted U-shaped relationship, representing the EKC hypothesis.

3.3 Definition and Measurement of Variables

3.3.1 Dependent Variables

The study uses two environmental variables to measure the environmental quality or effect. The first is CO2 emissions per capita (CO2/P); which has been described as a colourless and odourless gas produced by burning fossil fuels such as coal, oil and gas in their commercial and domestic activities. Given the growing usage of fossil fuels for the

production of goods and services, (CO₂) emissions have increased significantly in the past century (Boopen and Vinesh, 2010). Carbon dioxide (CO₂) emission is the major cause of global warming accounting for about 72% of emitted greenhouse gases (Sanglimsuwan, 2011).

The second variable is a sustainability indicator – Adjusted net savings (ANS) otherwise known as Genuine savings (GS). The pollution related variable in the classic EKC framework is replaced by a macroeconomic sustainable indicator, i.e., ANS in order to represent a more general framework geared towards sustainable development. The GS index provided by the World Development Report is formally expressed as follows:

$$GS = K^* - (F_R - f_R)(R-g) - b(e - d), \text{ where}$$

K^* represents economic capital formation while other terms are adjustments for consumption and degradation of natural capital (Hamilton, 2000). In particular, the economic value of natural resources consumption (resources extracted “R” minus natural growth rate “g” for renewables) is given by the resource rental rate (F_R) less the marginal cost of extraction (f_R), while pollution (emissions “e” minus natural dissipation rate “d”) is evaluated by the marginal cost of abatement “b”. GS is based on the assumption of perfect resource substitutability and it could therefore be interpreted as a limit value of sustainability, where

GS>0 Sustainability

GS=0 Minimum level of sustainability

GS<0 Non-sustainability.

Adjusted net saving (ANS) is a widely accepted indicator for weak sustainability based on the concepts of green national accounts and on the Hartwick rule for weak sustainability. If the 'Hartwick rule' is followed, such that rate of investment in produced capital just equals current scarcity rents on the exhaustible resource at each point in time, then there is a sustainable economy (Hartwick, 1977). On the basis of the Hartwick rule, a simple criterion for weak sustainability is that the value of natural capital plus manufactured capital should not be decreasing. Weak sustainability assumes that there are substitutes for all assets, whereas strong sustainability requires the preservation of critical natural capital in order for development to be sustainable.

ANS measures the rate of gross national savings as percentage of Gross National Income (GNI) after taking into account the depletion of fixed capital, education expenditures (in order to account for human capital formation), the depletion of certain natural resources (energy, minerals and net forest depletion) and pollution damages of carbon dioxide and particulate emissions (Hamilton, 2000).

This study employs lagged income variable as the explanatory variable in the ANS specification as done in Costantini and Martin (2007) and Kleeman et al. (2013). The rationale behind this is that ANS is measured as a percentage of GNI; as such using current income could result in biased estimates. It is important to note that unlike in the CO₂/P specifications, a positive coefficient for the ANS specification will indicate a move towards more sustainability.

3.3.2 Explanatory Variables

The choice of the explanatory variables for the study, are informed by economic theory and existing empirical studies. The variables include GDP per capita, GDP per capita squared, trade, FDI, population, regional dummies and interaction of GDP per capita and its square with the regional dummies.

These variables are discussed in the ensuing paragraphs with focus on their expected relationship with the environmental quality variables (CO₂ emissions and ANS). Data on all the variables are sourced from the World Development Indicators (WDI) Online Database of the World Bank, 2014.

3.3.2.1 Trade

One of the variables considered as vary important in contributing to the EKC is trade. From the empirical literature, the effect of trade on the environment has been ambiguous. While some studies finds it to be beneficial, others revealed it to be detrimental to the environment. Trade can either increase pollution by increasing the volume of exports which raises the size of the economy, thereby increasing pollution. Trade can also improve the environment through environmental regulation and innovation policies to reduce pollution as income increases via trade. It has been argued by Copeland et al. (2003) that if environmental quality is a normal good, then increases in income resulting from either trade or growth will cause an increase in both the demand for environmental quality and the ability of governments to afford expensive investments to safeguard the environment.

Trade openness is used as a measure of trade in this study and is defined as the sum of total exports and imports of goods and services expressed as a percentage of GDP. i.e. $((\text{Exports} + \text{imports}) / \text{GDP})$. Antweiler (2001), Sharma (2011), Jayanthakumaran (2012), Kleemann et al. (2013) and others have used the same measure in related works.

3.3.2.2 *Foreign Direct Investment (FDI)*

Foreign Direct Investment (FDI) refers to investment by foreign companies in overseas subsidiaries or joint ventures which has a traditional reliance on natural resource use and extraction, particularly in agriculture, mineral and fuel production. Though this balance has shifted in recent years, the poorest countries still receive a disproportionate amount of investment flows into their natural resource sectors- Maybe et al. (1999).

Developing and emerging nations over the past few decades has witnessed a sea change in FDI due to the removal of many restrictions on financial flows in and out of their countries. In particular, SSA has seen a substantial increase in FDI flows particularly in the first decade of the 21st century which saw FDI flows to the region more than double from an average of US\$ 14.9 billion in the first half of the decade (2001–2005) to US\$ 30.3 billion in the last half of the decade (2006–2010).

The greater mobility of capital, coupled with extensive privatisation and greater globalisation in production, has resulted in a five-fold rise in private investment flows since the early 1990. The past decade has also seen all trends of environmental degradation accelerate – for example, greenhouse gas emissions, deforestation, loss of biodiversity etc. Some studies such as Tamazian et al. (2009), Shahbaz et al. (2012) and

so on have also shown that, financial development are determinants of environmental quality and that, higher degree of financial development reduces environmental degradation. It is therefore critical to understand the environmental effects of private investment in SSA using a panel approach and identify appropriate responses.

FDI net inflows (% of GDP) is used as a proxy for financial development defined as the sum of equity capital, reinvestment of earnings, other long-term and short-term capital as shown in the Balance of Payments (BOP) as a percentage of GDP.

3.3.2.3 GDP Per Capita (GDP/P) and GDP Per Capita Squared (GDP/P)²

To test the existence or otherwise of the EKC, the GDP per capita and the square of GDP per capita are required. This is because based on the arguments of the EKC, environmental quality (measured by CO₂ emissions and ANS) increases in the early stages of economic growth, but beyond some level of income per capita, which vary for different indicators, the trend reverses, so that at high income levels, economic growth leads to environmental improvement.

Works by Shahbaz et al. (2012), Hossain (2012), Azumahou (2006), Iwata et al.(2010), He (2010), Franklin and Ruth (2010) and a host of others found economic growth to be a major contributor to CO₂ emissions by using GDP per capita as a proxy for economic growth and also included the squared of GDP as an explanatory variable to test the existence or otherwise of the EKC. Others such as Kleemann et al. (2013), Costantini and Martin (2007) and Costantini and Monni (2006) have also investigated the contribution of

economic growth to sustainability by using ANS (genuine savings) as an indicator for environmental sustainability.

On the basis of the EKC hypothesis, the coefficient of GDP per capita (GDP/P) and its squared are expected to be positive and negative respectively in order to reflect the inverted U-shaped curve.

3.3.2.4 Total Population (POP)

Total Population (POP) is used in this study to control for the effects of increasing population on the environment. The variable is defined as the total number of all persons resident in a country irrespective of their legal status or citizenship; except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. The variable has been used in works by as Muhammad et al. (2012), Muhammad et al. (2011), Hossain (2012) and so on in examining the environmental effects of various pollutants including CO₂ emissions through the EKC framework.

3.3.2.5 Regional dummies

These are introduced into the estimation equation to determine if significant differences exist between the various regional blocks of SSA regarding the effect of the explanatory variables on the environment. The regional dummies are for East Africa, Central (Middle) Africa, Southern Africa and West Africa. The regional dummies are generated

in such a way that for a particular regional dummy, countries in that region assume a value of 1 and all other countries assume 0 values in that data column.

These dummies are further interacted with the GDP per capita and its square in order to determine if the EKC exists for the various blocks and how it differs across the sub-region.

Table 4.1 below provides a summary of the explanatory variables, their proxies, and the expected sign of their coefficients.

Table 4.1: Summary of Variables, Proxies and Expected Signs.

| Variable | Description of measurement | Expected sign | Source of data |
|-----------------|---|----------------------|-----------------------|
| CO2/P | Per Capita CO2 emissions | | WDI, 2014 |
| ANS/P | Adjusted Net Savings. (% of GNI) | | WDI, 2014 |
| GDP/P | Per Capita GDP (in constant 2000 \$US) | Negative | WDI, 2014 |
| $(GDP/P)^2$ | Per Capita GDP (in constant 2000 \$US) | Positive | WDI, 2014 |
| TRADE | Measure of Trade Openness (Export + Import)/GDP | Negative/Positive | WDI, 2014 |
| FDI | Share of FDI (net inflows) in GDP | Negative/Positive | WDI, 2014 |
| POP | Total population | Negative/Positive | WDI, 2014 |

3.3 ESTIMATION TECHNIQUE

The model specified above is perceived to have endogeneity associated with it and as such using the Ordinary Least Squares (OLS) estimator produces biased and inconsistent estimates. Although many other estimation techniques could be used to estimate equation (3.3) in the presence of endogeneity, the dynamic panel model is best estimated using the General Method of Moments (GMM) estimation techniques. The “dynamic panel bias” problem resulting from endogeneity associated with the dynamic panel models are best resolved using the GMM procedure. Because the dynamic panel equation has the lagged dependent likely to correlate with the error term, it is likely to be confronted with the dynamic panel bias problem and as such, using the Ordinary Least Squares (OLS) in the estimations produces inconsistent and positive biases.

The GMM estimation procedure considers two special cases of estimation techniques. These are the Instrumental Variable (IV) and the Two-Stage Least Squares (2SLS) estimation techniques. These techniques could equally be used to estimate. By using external instruments, any of these techniques could equally be used to estimate the regression equation in which some variables are suspected to be endogenous. However, the limitation to using the external instrument is that they are usually weak and hardly satisfy the conditions of “validity and relevance” in order to yield unbiased estimates. It is also very difficult to obtain instruments which are correlated with the endogenous variables and at the same time uncorrelated with the stochastic error terms.

The GMM technique however, uses the lags of the endogenous variables as instruments. In doing this, the endogenous variables are predetermined and are therefore not correlated with the stochastic error terms. Furthermore, it has argued by Baum et al (2003) that in

the presence of heteroscedasticity, the GMM estimation techniques yield more efficient estimates than the 2SLS and the IV.

In a broader sense, Roodman (2006) reports the GMM estimation techniques to yield consistent and efficient estimates when the data-generating process exhibits the following features:

- There is a lagged dependent variable which affects the dependent variable.
- There exist country-specific fixed effects which are randomly distributed.
- There is country-specific serial correlation and heteroscedasticity in the stochastic error term.
- There is no correlation between the stochastic error terms across countries.
- The instruments are “internal”, that is, they are lags of the endogenous regressors.
- The time period (T) is small and the number of countries (N) is large.

The existing literature on dynamic panel models identifies two types of GMM estimation procedures. . These are the differenced GMM introduced by Arellano and Bond (1991) and the system GMM introduced by Arellano and Bover (1995) and Blundell and Bond (1998).

The differenced GMM estimation procedure corrects the inconsistency problem resulting from the endogeneity associated with some of the regressors. This procedure eliminates the source of the inconsistency in the estimation by applying the first difference operator to the estimation equation.

The equation is subsequently estimated by the differenced GMM after differencing. This is done by including the lags of the regressors as instruments. The differenced equation is of the form:

$$y_{it} - y_{i,t-1} = \alpha_1(y_{i,t-1} - y_{i,t-2}) + \alpha_2(x_{it} - x_{i,t-1}) + (v_{it} - v_{i,t-1}) \quad (3.4)$$

It has already been argued that by taking first differences of equation (3.3), equation (3.4) removes the unobserved country-specific effect and as a result tackling the inconsistency and biases resulting from the endogeneity of the explanatory variables by using lagged values of the endogenous explanatory variables as instruments.

Under the assumptions that the regressors are weakly exogenous and the error term is not serially correlated, the differenced GMM estimator is based on the following moment conditions:

$$E[y_{i,t-1}(v_{it} - v_{i,t-1})] = 0, \text{ for } t = 3, 4 \dots T \quad (3.5)$$

$$E[x_{i,t-1}(v_{it} - v_{i,t-1})] = 0, \text{ for } t = 3, 4 \dots T \quad (3.6)$$

Despite the merits for the use of the difference GMM, the procedure also has some statistical and conceptual shortcomings.

Firstly, if the time-invariant country-specific effects is of interest in the estimation process, there may be a misspecification problem if they are completely eliminated. Furthermore, if the dependent variable is highly persistent and the correlation between the instruments and the endogenous variables is weak (weak instruments), the process can result in serious biases.

Weak instruments are harmful to the small-sample and asymptotic properties of the differenced estimator. The weak instruments actually increase the variance of the coefficients and bias the coefficients in small samples.

The problem of weak instruments associated with the differenced GMM is intended to be rectified by the system GMM using the level equation and the difference equation. The endogenous variables in the level equation are instrumented by lag differences. These instruments are appropriate given the assumption that there may be correlation between the country-specific fixed effects and the right-hand side variables; and that the lagged differences and the country-specific fixed effects are uncorrelated.

The additional moment conditions relevant for appropriate instruments are stated below:

$$E[(y_{i,t-1} - y_{i,t-2})(u_i - v_{it})] = 0, t = 3, 4 \dots T \quad (3.7)$$

$$E[(x_{i,t-1} - x_{i,t-2})(u_i - v_{it})] = 0, t = 3, 4 \dots T \quad (3.8)$$

Roodman (2006), has argued that the efficiency of the estimation equation would be greatly improved when the moment conditions of its level form and first difference forms are combined. Hence, given that the dependent variable is persistent, the system GMM estimator is preferred to the differenced GMM.

In addition, for the system GMM estimator to give consistent and reliable estimates, the instruments used must be valid. Major tests conducted to determine the validity of the instruments include the Sargan test and the Arellano-Bond test. The Sargan test of overidentifying restrictions tests the null hypothesis that the overidentifying restrictions

are valid while the Arellano-Bond test is used to examine the hypothesis that there exists no serial correlation between the error terms.

In summary, the system GMM is preferable to the other estimation techniques because:

- It overcomes the problem of endogeneity through the use of lagged values of explanatory variables as instruments.
- It eliminates the problem of information loss in cross-sectional regressions as it allows for multiple observations for each country across time.
- It allows for the use of level and lagged values of the variables in the estimation equation.
- It is able to give consistent estimates even when T (time periods in years) is small and N (countries) is large.

3.5 Diagnostic Tests

3.5.1 Endogeneity

Endogeneity is said to exist if there is correlation between any of the explanatory variables and the random error term. Reasons for the occurrence may be as a result of omitted variable bias, measurement error or reverse causality.

Thus, in the presence of endogeneity, $Cov(\mu_i, x_{it}) \neq 0$

Where μ_i is the time-invariant country-specific effect; and x_{it} is the set of explanatory variables.

The dynamic panel equation (Equation 3.3) specified above may suffer from the problem of endogeneity. This is due to the introduction of the lagged of the environmental quality

variable which is expected to influence the value of variable in the current period. There also exist evidence of reverse causality between FDI and GDP per capita and also trade and GDP per capita.

The likely evidence of reverse causality raise suspect of these variables being endogenous in the regression model. A Durbin–Wu–Hausman (DWH) test for endogeneity would be conducted for the residuals of all suspected endogenous explanatory variables as a function of all the exogenous variables (Alemu and Yokoyama, 2009).

In the presence of endogeneity, OLS estimation technique yields biased and unreliable estimates whereas the system GMM estimation technique produces consistent estimates.

3.5.2 Autocorrelation and Heteroscedasticity.

The two main sources of persistence likely to be associated with the panel model in equation (4.2) over time are autocorrelation and heteroscedasticity. The case of autocorrelation arises due to the presence of the lagged dependent variable in the right hand side of the regression. If the dependent variable is a function of a component of the error term, then its lag is also a function of the error term. Autocorrelation can also be described as a mathematical representation of the degree of similarity between a given time series and a lagged version of itself over successive time intervals. Taking a lag of equation (4.2) gives the following equation:

$$y_{i,t-1} = \alpha y_{i,t-2} + x'_{i,t-1} \beta + \mu_i + v_{i,t-1} \quad (3.9)$$

It can be observed from (3.4) and (3.9) that the dependent variable and its lag are both functions of the country–specific time–invariant component of the error term. This shows that the dynamic panel model is associated with autocorrelation.

Another issue of persistence associated with the dynamic panel model is heterogeneity among the countries as a result of individual country-specific effects. The loud presence of the unique economic, social and geographical characteristics which exist between the countries under study must be considered in the estimation procedures. Without this consideration, the OLS estimator will result in biased and inconsistent estimates even if the error term is not serially correlated.

3.5.3 Fixed Effects (FE) versus Random Effects (RE)

The econometrics literature makes two different assumptions concerning the correlation between the time-invariant error term (i) and the explanatory variables in the econometrics literature. These assumptions result in the Fixed Effects (FE) and Random Effect (RE) models. Two different assumptions are made regarding correlation between the time-invariant error term (μ_i) and the explanatory variables in the econometrics literature. These assumptions result in the Fixed Effects (FE) and Random Effect (RE) models.

In a random effects model, the unobserved variables are assumed to be uncorrelated with (or, more strongly, statistically independent of) all the observed variables. More specifically, the RE model assumes that the unobserved country-specific time-invariant effects are uncorrelated with the explanatory variables. The model is used when variation across countries is assumed to be random and uncorrelated with the explanatory variables.

$$Cov(\mu_i, v_{it}) = 0$$

The country-specific characteristics are included as explanatory variables in the estimation equation for the RE model. These country-specific characteristics may include policies on natural resource extraction, traditional industrial activity or service industries, cultural differences, dissimilarities in climate and natural resource endowment, or different approaches towards environmental protection in the policy agenda and geographical factors which are mostly unique for each country and are time-invariant. The assumption of uncorrelated country-specific time-invariant error terms and the regressors is upheld by the RE model and as such allows for time-invariant variables to be included in the model as explanatory variables. These individual characteristics which may either influence the explanatory variables or not need to be well specified. However, from the dynamic panel model specified, whereas the explanatory variables (x_{it}) can easily be observed, that of the time-invariant country specific effects (μ_i) cannot be easily observed.

The fixed effects (FE) model on the other hand assumes that the country-specific time-invariant effects are correlated with the explanatory variables, and thereby controls for them. In other words, the fixed effects models control for, or partial out, the effects of time invariant variables with time invariant effects. This is true whether the variable is explicitly measured or not. The model is suitable on the assumption that the countries possess certain individual characteristics which are unique to them and are time-invariant. The time-invariant effects from the estimation is eliminated by using the within transformation to demean the variables. The within subject means for each variable (both the Xs and the Y) are subtracted from the observed values of the variables. Hence, within each subject, the demeaned variables all have a mean of zero.

The within transformation process is described with reference to equation (3.3) below:

$$y_{it} - \bar{y}_i = (x_{it} - \bar{x}_i)\beta + (\mu_i - \bar{\mu}_i) + (v_{it} - \bar{v}_i) \quad (3.10)$$

Where, $\bar{y}_i = \frac{1}{T} \sum_{t=1}^T y_{it}$, $\bar{x}_i = \frac{1}{T} \sum_{t=1}^T x_{it}$, $\bar{v}_i = \frac{1}{T} \sum_{t=1}^T v_{it}$, $\bar{u}_i = u_i$,

In the within transformation process described in equation (3.10), the mean of the variables are calculated and subsequently subtracted from their actual values; and since the country-specific error terms (u_i) do not change over time, its mean value (\bar{u}_i) is the same as the actual values. This process therefore eliminates the country-specific effects from the equation. The presence of heteroscedasticity in the estimation model would therefore favour the FE model, as it assumes heterogeneity in the error term across countries. The Hausman test is used to choose between random effect and fixed effect for the estimation. The GMM estimation procedure would yield reliable estimates if the data fits the fixed effects model.

3.5.4 Stationarity (Unit Root) Test

Stationarity test or the problem of unit root is generally viewed as a problem associated with time series. However, undertaking such tests in panel datasets could also be very appropriate in order to ensure that the variables under study are stationary. This process helps in avoiding the trap of spurious regressions which relates to the occurrence of unrelated regressions. It has been stated by Gujarati (2003 pp.713), that “a stochastic process is said to be stationary, if its Mean, and Variance are constant overtime and the value of Covariance between two time periods depends only on the distance between the

two time periods and not on the actual time at which the Covariance is computed". The Fisher test for stationarity is adopted by this study. This is chosen based on the strength it possesses above other tests. According to Choi (2001), the Fisher test may be preferred to other tests because of the following reasons:

- It does not require a balanced panel as in the case of the IPS test
- Different lag lengths can be used in the individual ADF regressions.
- It can be carried out for any unit root test.
- It does not require simulating adjustment factors that are specific to the sample size and specification.

3.5.5 Other Diagnostic Tests

The system GMM estimation procedure requires certain vital considerations to be fulfilled in order to ensure that its estimates are reliable. In the first place, for the system GMM estimates to be upheld as valid, the error terms are not to be with higher order autocorrelation. This study will adopt the Arellano–Bond test for second order autocorrelation in first differenced errors to test for serial autocorrelation in the idiosyncratic errors.

Another issue worth investigating is the validity of the instruments used in the estimation procedures. For the system GMM estimates to be deemed valid and give reliable estimates, the instruments must also be valid. This requires that the conditions of relevance (correlation between the instruments and the endogenous explanatory variables) and exogeneity (instruments are orthogonal to the residuals) must be satisfied.

Thus, the instruments used must be truly exogenous; such that there should be no correlation between the residuals and the explanatory variables and the instruments must be correlated with the endogenous explanatory variables. The Sargan test under the null hypothesis that the overidentifying restrictions are valid can be used to test the validity of the instruments. Hansen (1982) has also suggested a test procedure that could be used to test the validity of the instruments. However, as the number of instruments increases, the Hansen test becomes weaker making the Sargan test more appropriate.



CHAPTER FOUR

DATA ANALYSIS AND DISCUSSION OF RESULTS.

4.1 Introduction

The estimation and discussion of results for this study is presented in this chapter. The chapter is in seven sections. A descriptive analysis of the variables and the test for unit root are presented in the next two section; followed by the estimation results which answer the research questions of the study in section 4.4. Some diagnostic tests are explored and carried out in section 4.5. Section 4.6 discusses the empirical findings for the study; followed by some concluding remarks in section 4.7.

4.2 Descriptive Analysis

The study considers thirty-seven (37) SSA countries for the period 1990-2013. The descriptive statistics under consideration are the mean, the standard deviation, and the minimum and maximum values of the variables. The descriptive statistics is reported in Table 4.1



Table 4.1: Descriptive Statistics of Variables.

| VARIABLE | Observations | Mean | Standard deviation | Minimum | Maximum |
|---------------------------|--------------|-----------|--------------------|----------|----------|
| Adjusted Net Savings | 723 | -2.667247 | 22.36147 | -242.428 | 38.8411 |
| CO2 per capita | 777 | .7374162 | 1.723278 | .011343 | 10.584 |
| Per capita GDP | 888 | 1369.583 | 2133.879 | 113.877 | 15098.6 |
| Trade Openness | 883 | 71.53359 | 47.54138 | 10.7483 | 531.737 |
| Foreign Direct Investment | 881 | 3.643782 | 8.665445 | -8.58943 | 161.824 |
| Total Population | 888 | 1.78e+07 | 2.47e+07 | 373851 | 1.70e+08 |

Source: Author's Computation with data from WDI.

The number of observations and mean values of the variables are reported in the second and third columns respectively. It can be observed that total population has the largest mean of 17800000 while ANS recorded the least mean of -2.667247. The fourth column shows the standard deviation of the variables. It can be seen that total population has the largest dispersion of 24700000 whereas CO2 emissions per capita has the lowest dispersion of 1.723278. The minimum and maximum values of each variable as used in the study are reported respectively in columns five and six.

In addition, the performance of the variables for the study within the sub-regional blocks namely Southern African Development Community (SADC), East African Community (EAC), Economic Community of West African States (ECOWAS) and the Central African Economic and Monetary Community (CEMAC) are illustrated in Table 4.2. It

can be observed from the table that countries in SADC contributes positively to ANS with an average of 11.24773 whereas those in CEMAC are the least contributor; recording -20.4801 on the average. The overall mean value of ANS for the countries under study within the sub-region is -2.667247.

Also, per capita CO₂ emissions and GDP are highest for SADC countries recording an average of 2.636403 and 3333.783 respectively but lowest for ECOWAS countries accounting for 0.2473797 and 497.6475 in the same order.

CEMAC receives the largest values of trade and foreign direct investment of 97.6693 and 6.539707 respectively. However those in EAC is the least performing sub-regional block in terms of trade and FDI inflows recording an average of 56.70429 and 2.347256 respectively.

Table 4.2: Performance of Variables in Sub-Regional Blocks.

| VARIABLE | EAC | ECOWAS | CEMAC | SADC | SSA |
|----------------------------|-----------|----------|----------|----------|-----------|
| Adjusted Net Savings | -.2274724 | -.887593 | -20.4801 | 11.24773 | -2.667247 |
| CO ₂ per capita | .3025462 | .2473797 | .8906603 | 2.636403 | .7374162 |
| Per capita GDP | 722.2238 | 497.6475 | 2277.88 | 3333.783 | 1369.583 |
| Trade Openness | 56.70429 | 61.63344 | 97.6693 | 91.27054 | 71.53359 |
| Foreign Direct Investment | 2.347256 | 2.68575 | 6.539707 | 3.259563 | 3.643782 |
| Total Population | 2.10e+07 | 2.00e+07 | 1.29e+07 | 1.20e+07 | 1.78e+07 |

Source: Author's Computation Using Data from WDI.

4.3 STATIONARITY TEST (UNIT ROOT TEST).

The stationary properties of the various variables is tested by employing the Fisher test. Performing such a test is very necessary as it avoids the occurrence of unrelated regressions or spurious regressions. The null hypothesis of the test requires that all the panels contain unit roots. In order to have a healthy check, all four unit root test statistics associated with the Fisher test are reported (see Table 4.3). It has been argued by Choi (2001) that when the number of panels is finite, the inverse chi-squared test is most appropriate for testing unit root. Given the finite number of panels for this study, the null hypothesis of unit roots is rejected for all the variables on the basis of the inverse chi-square test statistic. It must also be noted that, aside the inverse chi-squared test all the other tests reported significant results of all the variables except total population, where the inverse normal and inverse logit test statistics were insignificant. The conclusion drawn is that at least one of the panels has no unit root and the tendency of possible spurious regressions or unrelated regressions is removed.

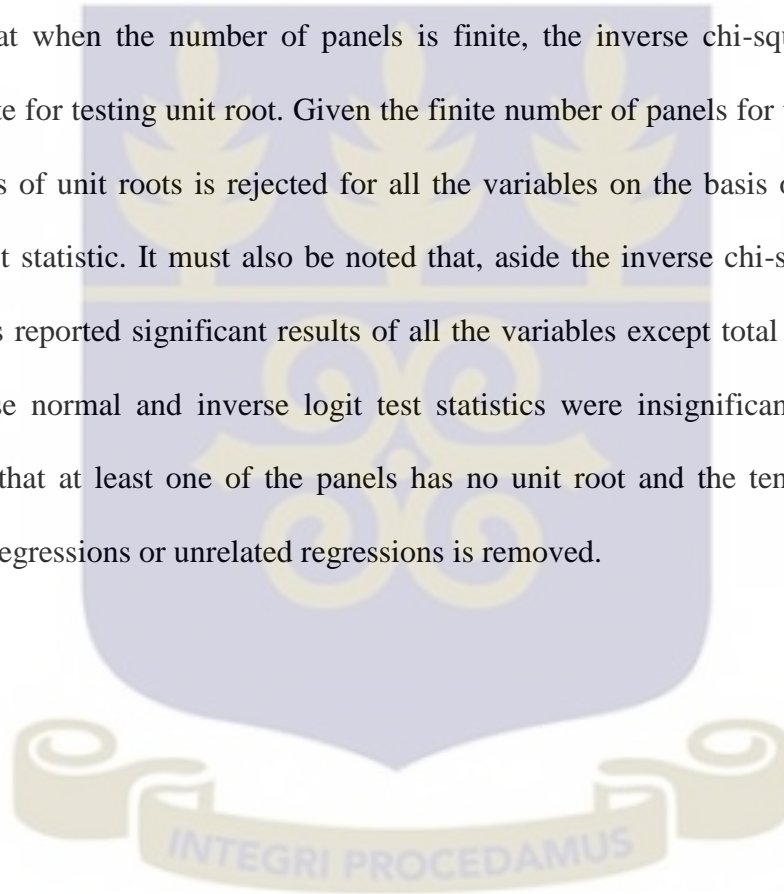


Table 4.3: Fisher–Type Stationarity (Unit Root) Test

| Variable | Inverse chi-squared | | Inverse Normal | | Inverse Logit t | | Modified inv. Chi-squared | |
|---------------------------------|---------------------|--------|----------------|--------|-----------------|--------|---------------------------|--------|
| | Statistic | Prob. | Statistic | Prob. | Statistic | Prob. | Statistic | Prob. |
| CO2 per capita (CO2/P) | 176.2768 | 0.0000 | -6.7644 | 0.0000 | -6.9579 | 0.0000 | 8.4071 | 0.0000 |
| Adjusted Net Saving (ANS) | 115.7728 | 0.0008 | -2.4831 | 0.0065 | -2.6810 | 0.0040 | 3.6477 | 0.0001 |
| Per capita GDP(GDP/P) | 138.2019 | 0.0000 | -2.4755 | 0.0067 | -2.7431 | 0.0033 | 5.2774 | 0.0000 |
| Trade Openness (TOP) | 111.6994 | 0.0031 | -1.7990 | 0.0360 | -1.9293 | 0.0276 | 3.0989 | 0.0010 |
| Foreign direct investment (FDI) | 182.0605 | 0.0000 | -5.2425 | 0.0000 | -6.2051 | 0.0000 | 8.8825 | 0.0000 |
| Total Population (POP) | 139.2330 | 0.0000 | 0.3536 | 0.6382 | -1.2538 | 0.1058 | 5.3621 | 0.0000 |

Source: Author's Computation Using Data from WDI.

4.4 Estimation of Results

In this section, the estimation results based on the EKC hypothesis using the system GMM estimator are presented. The regression results estimated for the thirty-seven (37) SSA countries for the period 1990-2013 are displayed in Table 4.4 and Table 4.5 for the CO2 and ANS specifications respectively.

In the first regression model for both specifications, all the explanatory variables are displayed with the exception of the regional dummies and the interacted variables. With this regression, the overall effects of all the variables can be analysed for all the countries under study. In analyzing the sub-regional performance, the regional dummies are later added to the variables in the first model to perform the second regression model. In the last regression models, the interacted variables of per capita GDP and its squared with the regional dummies are introduced into the model together with the other explanatory variables. This is to analyse the existence or other wise of the EKC hypothesis in each of the sub-regions. It is important to note that for the last model, regional dummies are not included because they show severe collinearity with the interacted variables.

From both results, the significant Wald Chi-squared for all the regressions shows that the explanatory variables are jointly significant. The Arellano-Bond test AR (2) in first differences fails to reject the null hypothesis of no two-period serial correlation in the residuals at all traditional significant levels (1%, 5% and 10%) for the CO₂/P specification but at 5% for the ANS specification. Also, the Sargan test for overidentifying restrictions shows that the overidentifying restrictions are valid in the models; hence the models are not weakened by too many instruments. One period lags of the endogenous variables are used as instruments for the first difference equation whilst first difference of the endogenous variables are used as instruments for the levels equation.

Table 4.4: System GMM Estimations based on the EKC framework with CO2 per capita emissions as dependent variable.

| VARIABLES | 1 | 2 | 3 |
|---|-----------------------|------------------------|------------------------|
| Lagged CO2 per capita emissions | 0.834***(0.000261) | 0.850***(0.00193) | 0.865***(0.00209) |
| Economic Growth | 0.000488***(5.90E-07) | 0.000766***(5.49E-06) | 0.00857***(0.00077) |
| Economic Growth squared | -2.92e-08***(0.0000) | -4.54e-08***(1.97E-10) | -5.37e-06***(5.38E-07) |
| Trade Openness | 2.78e-05***(1.19E-05) | 0.000680***(3.70E-05) | -5.29E-05(5.81E-05) |
| Foreign Direct Investment | 0.00406***(1.60E-05) | 0.00547***(7.86E-05) | 0.00533***(0.000109) |
| Total Population | 8.16e-09***(1.27E-10) | -1.16e-08***(9.20E-10) | 2.32E-10(8.52E-10) |
| EAC | | -4.400***(0.592) | |
| CEMAC | | -4.223***(0.47) | |
| SADC | | -3.643***(0.467) | |
| EAC*Economic Growth | | | -0.00819***(0.000789) |
| CEMAC*Economic Growth | | | -0.00790***(0.000769) |
| SADC*Economic Growth | | | -0.00783***(0.000764) |
| EAC*Economic Growth squared | | | 5.33e-06***(5.39E-07) |
| CEMAC*Economic Growth squared | | | 5.32e-06***(5.37E-07) |
| SADC*Economic Growth squared | | | 5.30e-06***(-5.37E-07) |
| Constant | -0.498***(-0.00221) | 2.347***(-0.492) | -1.183***(-0.0595) |
| Observations | 733 | 733 | 733 |
| Number of Code | 37 | 37 | 37 |
| Wald Chi -squared (Prob> Chi – squared) | 0 | 0 | 0 |
| Arellano–Bond [AR(2), Prob> Z] | 0.2623 | 0.406 | 0.3567 |
| Sargan test (Prob>Chi-squared) | 1.0000 | 1.0000 | 1.0000 |

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's Computation Using Data from WDI.

Table 4.5: System GMM Estimations based on the EKC framework with ANS as the dependent variable

| VARIABLES | 1 | 2 | 3 |
|--|------------------------|---------------------|----------------------|
| Lagged Adjusted Net Savings | 0.483***(0.0156) | 0.448***(0.00782) | 0.415***(0.00745) |
| lagged Economic Growth | 0.00944***(0.00137) | -0.00491**(0.00203) | -0.0324(0.028) |
| lagged Economic Growth squared | -1.28e-06***(2.07E-07) | 8.95E-08(2.38E-07) | 3.84E-05(2.41E-05) |
| Trade Openness | -0.197***(0.0133) | -0.222***(0.013) | -0.176***(0.0157) |
| Foreign Direct Investments | -0.798***(0.0211) | -0.757***(0.0328) | -0.851***(0.0419) |
| Total Population | 1.35E-08(0.0328) | 5.08E-08(4.66E-08) | -1.05E-08(1.27E-07) |
| EAC | | -8.658(5.419) | |
| CEMAC | | 8.626**(3.719) | |
| SADC | | 51.47***(8.569) | |
| EAC*Lagged Economic Growth | | | 0.0204(0.0253) |
| CEMAC*Lagged Economic Growth | | | 0.0265(0.0265) |
| SAC*Lagged Economic Growth | | | 0.0479*(0.0274) |
| EAC*Lagged Economic Growth Squared | | | -3.79E-05(2.37E-05) |
| CEMAC*Lagged Economic Growth Squared | | | -3.81E-05(2.41E-05) |
| SAC*Lagged Economic Growth Squared | | | -4.02e-05*(2.40E-05) |
| Constant | 8.149***(2.308) | 14.24***(4.128) | 16.22***(4.068) |
| Observations | 677 | 677 | 677 |
| Number of code | 37 | 37 | 37 |
| Wald Chi -squared (Prob> Chi -squared) | 0.0000 | 0.0000 | 0.0000 |
| Arellano–Bond [AR(2), Prob> Z] | 0.0547 | 0.0704 | 0.077 |
| Sargan test (Prob>Chi-squared) | 1.0000 | 1.0000 | 1.0000 |

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Source: Author's Computation Using Data from WDI.

4.5 Diagnostic Tests

Under this section, various tests are performed to ensure that the data fits the model and also to confirm the validity and reliability of the results from the system GMM estimations. The diagnostic tests performed include autocorrelation, overidentification restrictions, endogeneity, heteroscedasticity and the choice of fixed and random effects models.

4.5.1 Autocorrelation

The Arellano–Bond test is performed to test for autocorrelation in the first difference errors.

Outcomes of the test are reported together with the estimation results in tables 4.41 and 4.42 for the CO₂/P and ANS specifications respectively. The null hypothesis of no autocorrelation in second order is not rejected for all the regressions. More specifically, the null hypothesis of no autocorrelation in second order is rejected at 5% significance level for the ANS specification model whiles the CO₂/P specification rejected it at all significant levels. This suggests that there is no correlation between the error terms and hence the condition of no autocorrelation is satisfied. This therefore give way for the use of the system GMM estimation procedure.

4.5.2 Validity of Overidentifying Restrictions

In order to produce consistent estimates, the system GMM estimation technique requires that the instruments used must be valid.

This can be verified by using the Sargan test of overidentifying restrictions which adopts the null hypothesis of valid overidentifying restrictions in its test. The results for the test is reported together with the estimation results (see tables 4.41 and 4.4.2). The null hypothesis of overidentifying valid restrictions fails to be rejected by the test since the p-value is 1.000 for all the regression equations. This implies that, with the evidence of no autocorrelation and the satisfaction of the condition of valid instruments, the system GMM estimator qualifies to yield consistent and reliable estimates.

4.5.3 Endogeneity

The Durbin–Wu–Hausman (DWH) test is employed to substantiate the existence of endogeneity among some of the variables. The null hypothesis assumed for this test is that the regressors are uncorrelated with the error term. If this is found true, then the OLS estimation will be appropriate since the variables are uncorrelated with the error term.

On the other hand, the rejection of the null hypothesis implies that the variables are endogenous and as such the OLS estimators are inconsistent. In this case, the strict exogeneity assumption of the explanatory variables with the idiosyncratic errors is dropped. As a result, there is a clear indication that the system GMM approach which is designed under the assumption of endogeneity of the explanatory variables fits the model and its estimates are consistent and efficient. In dealing with the problem of endogeneity, the system GMM approach generates appropriate instruments for the explanatory variables suspected to be endogeneous.

The results of the Durbin–Wu–Hausman (DWH) test show that GDP per capita, lag of GDP per capita, trade, foreign direct investment and total population are correlated with the error term (see Table 4.4 and Table 4.5). In table 4.6 and table 4.7, the p-value of 0.0006 and 0.0000 for all the variables for the CO2/P and ANS specifications respectively implies a rejection of the null hypothesis of no endogeneity. This suggests that the regressors are endogenous which allows them to be instrumented with suitable instruments. The strict exogeneity of the independent variables with the idiosyncratic errors fails to hold in this case. Given that the system GMM is developed under the assumption of endogeneity of the explanatory variables, it signals that the system GMM approach suits the model and would produce consistent and efficient estimates.

Table 4.6: Durbin–Wu–Hausman (DWH) Test for Endogeneity (CO2/P Specification)

| | P-value (Prob> Chi2) |
|---|--|
| Null Hypothesis | |
| Gross Domestic Product Per Capita is uncorrelated with the error term | 0.0006 |
| Trade [(Exports + Imports)/GDP] is uncorrelated with the error term | 0.0006 |
| Foreign Direct Investment is uncorrelated with the error term | 0.0006 |
| Total Population is uncorrelation with the error term | 0.0006 |
| The square of GDP Per Capita is uncorrelated with the error term | 0.0006 |

Note: The residuals of the variables are predicted and tested for significance after regressing them on all the other exogenous variables.

Source: Author's Computation Using Data from WDI.

Table 4.7: Durbin–Wu–Hausman (DWH) Test for Endogeneity (ANS Specification)

| Null Hypothesis | P-value (Prob> Chi2) |
|---|------------------------------------|
| Lag of GDP Per Capita is un correlated with the error term | 0.0000 |
| Trade [(Exports + Imports)/GDP] is uncorrelated with the error term | 0.0000 |
| Foreign Direct Investment is uncorrelated with the error term | 0.0000 |
| Total Population is uncorrelated with the error term | 0.0000 |
| The square of lagged GDP Per Capita is uncorrelated with the error term | 0.0000 |

Note: The residuals of the variables are predicted and tested for significance after regressing them on all the other exogenous variables.

Source: Author's Computation Using Data from WDI.

4.5.4 Heteroscedasticity

The Breush-Pagan/Cook-Weisberg test is conducted to determine the presence of heteroscedasticity. The test confirms the presence of heteroscedasticity at all traditional significant levels for both CO2/P and ANS specifications (see Table 4.8 and Table 4.9). With both specifications producing a p-value of 0.0000, the test rejects the null hypothesis of homoscedasticity. The model can therefore not be estimated using the OLS technique since it will produce biased and inconsistent estimates resulting in unreliable results. However, even in the presence of heteroscedasticity the system GMM is designed to yield consistent and unbiased estimates.

Table 4.8: Breusch-Pagan / Cook-Weisberg test for Heteroskedasticity

| |
|-----------------------------------|
| Ho: Constant variance |
| Variables: fitted values of CO2/P |
| |
| chi2(1) = 1983.84 |
| Prob> chi2 = 0.0000 |

Source: Author's Computation Using Data from WDI.

Table 4.9: Breusch-Pagan / Cook-Weisberg test for Heteroskedasticity

| |
|---------------------------------|
| Ho: Constant variance |
| Variables: fitted values of ANS |
| |
| chi2(1) = 88.51 |
| Prob> chi2 = 0.0000 |

Source: Author's Computation Using Data from WDI.

4.5.5 Fixed Effects and Random Effects

Another major requirement for the use of the system GMM estimation technique is a model that fits fixed effects. The assumption of the fixed effects model means that the unobserved country-specific effects vary across countries. This is confirmed by the presence of heteroscedasticity which implies the existence of heterogeneity across countries. The Breusch–Pagan / Cook-Weisberg test for heteroscedasticity (see Tables 4.10 and 4.11) confirms the presence of heteroscedasticity thereby indicating fixed effects model would be appropriate. Also the Hausman test which determine whether the fixed or random effects models fit the data for estimation rejects the null hypothesis that favours random effects model in both the per capita CO2 emissions and ANS specifications at all traditional significant levels of significance.

Table 4.10: Hausman Test for Fixed versus Random Effects

Test: Ho: difference in coefficients not systematic (CO2/P)

$$\chi^2(7) = (b-B)'[(V_b - V_B)^{-1}](b-B)$$

$$= 65.13$$

$$\text{Prob} > \chi^2 = 0.0000$$

Source: Author's Computation Using Data from WDI.

Table 4. 11: Hausman Test for Fixed versus Random Effects

Test: Ho: difference in coefficients not systematic(ANS)

$$\chi^2(7) = (b-B)'[(V_b - V_B)^{-1}](b-B)$$

$$= 32.25$$

$$\text{Prob} > \chi^2 = 0.0000$$

Source: Author's Computation Using Data from WDI.

Given the foregoing diagnostic tests, it has been shown that the system GMM estimation technique remains appropriate for the estimations as its estimates are dependable.

4.6 Discussion of Results

The main findings of the study are thoroughly discussed in this section. The section is broadly divided into three sub-sections. First the findings from the CO2 per capita emissions specification and ANS specification on the entire SSA as estimated in the first regression of both models is discussed. This is followed by assessing the environmental effects of the relevant variables within the sub-regional blocks. The section will then conclude on the issue of the EKC hypothesis in the sub-regional blocks.

4.6.1 Full Model: The Impact of All Countries in SSA under Study.

The first regression model in table 4.4.1 and table 4.4.2 are meant to explain the overall impact of the explanatory variables on per capita CO₂ emissions and ANS respectively for the 37 SSA countries under study. In the regression for per capita CO₂ emissions, a positive coefficient on a variable indicates a decrease in environmental quality or a rise in environmental deterioration. However, for the estimations in ANS, a positive coefficient on a regressor predicts a move towards an increase in environmental sustainability and vice versa.

From Tables 4.4 and 4.5, it is evident that the lags of per capita CO₂ emissions and ANS are significant and positive. This endorses the systematic nature of these measures of environmental quality. Given these positive coefficients, it can be interpreted that CO₂ emissions in some previous years tend to harm the environment even in the current year. This agrees with the findings of Stern (2008) who argues that much effort is required in reversing a deteriorated environment to its former state. Specifically, stern estimated that the cost of not dealing with current pollution will correspond to at least 5% loss of global GDP each year. Similarly, the higher the sustainability of the environment (as measured by ANS) in some previous year, the higher the environmental sustainability in the current year and the reverse is also true.

It can be observed that in the per capita CO₂ emissions specification, all the explanatory variables are significant. Specifically, economic growth, economic growth squared, foreign direct investment and total population are significant at 1% while trade is significant at 5%. Similarly for the ANS specification, it can be seen that all the explanatory variables apart from total population are significant at 1%. It can also be

observed that all the coefficients of the regression variables have their expected theoretical signs.

Economic growth measured as Gross Domestic Product per capita (GDP/P) produced a positive coefficient of 0.000488 for CO₂ emissions. This implies that, holding all other variables constant, a dollar increase in GDP/P will result in an increase in CO₂ per capita emissions of 0.000488 kilotons (0.488 metric tons). This can be attributed to the possible weak environmental regulations and administration within the sub-region. However as economic activities keep increasing, as indicated by the square of GDP/P, CO₂ per capita emissions begins to fall. This can be observed from the negative sign of economic growth squared variable of -0.0000000292.

With regards to the validity of the EKC hypothesis, the coefficients of economic growth and its squared of 0.000488 and -0.0000000292 respectively implies the existence of the EKC hypothesis for CO₂ per capita emissions in SSA. The occurrence of the EKC relationship for CO₂ in SSA can be attributed to the possibility that the technique effect in the later stages of development could cause a declining trend of the rising scale effect in the initial stages of production. Similarly, there is evidence for an inverted U-shaped curve relationship between lagged per capita GDP and ANS since the coefficients of lagged economic growth and its squared are positive and negative respectively; hence confirming the validity of the EKC hypothesis for ANS. To be more specific, an increase in economic growth by a dollar results in an increase in ANS by 0.00944 but as economic activities increases within the sub-region, there is a negative influence on ANS of -0.00000128 all things being equal.

The plausible reason for the presence of the EKC for ANS in SSA could be attributed to the fact that, in the fundamental estimation of the values for ANS, specific adjustments for consumption and degradation of natural capital are deducted from the total economic capital formulation of a particular economy (Hamilton, 2000). Given the current poor stance and the weak environmental norms of the sub-region, expected capital formulation is likely to be low compared to the demand on consumption and natural capital degradation. For this reason, continue desire for growth could result in a declining effect on sustainability if prudent measures are not implemented to add on to current capital formulation.

These results discussed above indicate that both per capita CO₂ emissions and ANS in SSA initially increases with per capita GDP up to a threshold level and decreases with further increases in GDP per capita, yielding an inverted U-shaped relationship. The study therefore predicts that CO₂ emissions and ANS would have a decline effect as the SSA economy expands beyond some threshold level. In the literally sense, economic growth in the initial stages of development in SSA worsens the quality of the environment by increasing per capita CO₂ emissions but supports the sustainability of the environment. As growth improves in the sub-region, there is a reducing effect on CO₂ emissions but sustainability of the environment falls. The net effect will therefore depend on whether the gains from ANS in the initial stages is enough to sustain the environment in the latter stages of increasing growth.

The findings are consistent with the findings of Abimbola et al. (2010) and O.A. Olusegun (2009) where they estimated an EKC model for CO₂ for a time series data set in Nigeria and obtained a U- shaped relationship between per capita GDP and CO₂

emissions per capita. The findings are also in consonance with Samimi et al. (2011) where they estimated and evaluated the relationship between environmental sustainability index (ESI) and economic growth in developing countries during 2001-2005. In accordance to theoretical priors, the results revealed that the coefficient of GDP per capita is positive and statistically significant and the coefficient of GDP per capita squared is negative and significant. Based on these coefficients, there is an inverted-U curve regarding the relationship between environmental sustainability and economic growth.

The coefficients of trade openness and foreign direct investment are positive implying that increases in trade openness and FDI are associated with increase in per capita CO₂ emissions and vice versa. In particular, all other things constant, a unit increase in trade and FDI will lead to an increase of 0.0000278 kilotons (0.0278 metric tons) and 0.00406 kilotons (4.06 metric tons) in CO₂ emissions respectively. On the contrary, openness of trade and FDI have negative effects on ANS. The coefficients of -0.197 and -0.798 for trade and FDI indicate that for the sub-region, sustainability is reduced by 0.197 and 0.798 for every unit increase in trade and FDI respectively with all other variables constant.

This stands to reason that, increases in trade and FDI tend to have a worsening impact on environment irrespective of which measure is used. This phenomenon has been described as the “race to the bottom” hypothesis which posits that international trade and investment create downward pressure on environmental regulations in host countries (Zhang, 2012). This can be attributed to the implementation of various policies in SSA countries aiming to improve their economies by allowing open trade and increasing the

attractiveness of the economy to foreign direct investment without counter measures fashioned to check the negative environmental externality resulting from it as argued by Morris (2008).

The harmful effect of FDI on environmental quality as measured by CO₂/P established here agrees with the findings of Mizan and Halimaliton (2012) and Shahbaz et al. (2012) but contrast with Liang (2006). In particular, the study by Mizan and Halimaliton (2012) found FDI to be a significant determinant of CO₂ emissions and assert that, a 1% increase in FDI leads to a rise in CO₂ emissions by 2.03%. They conclude that environmental quality in Malaysia becomes worse with the development of FDI. In contrast, Liang (2006) found a negative correlation between FDI and air pollution, suggesting that the overall effect of FDI may be beneficial to the environment. Liang's finding further suggests the argument that FDI in developing countries are more likely to act as a conditional factor for advanced and cleaner environmental technologies.

In addition, the negative effect of trade openness on environmental sustainability is in line with the findings of Samimi et al. (2011) where they found that coefficient of openness to be positive and significant. However, this conclusion is contradicted by the findings of Abdulia and Ramsecke (2009) where they found trade openness to be negatively related to ANS for 94 low and high income countries from 1990-2003.

Furthermore, the positive relationship between trade openness and CO₂/P established in this study is consistent with the conclusion of Copeland and Taylor (1994) where trade openness increases the pollution level in most developing countries. This view is however in sharp contrast with the study of Shahbaz et al. (2012) in which a long run

relationship was found between trade openness (exports+ imports) and CO2 emissions for Indonesia over the period of 1975Q1-2011Q4 and concludes that trade openness plays a role in improving environmental quality.

Total population is also positively associated with both CO2 emissions per capita and ANS. However, it is significant at 1% level of significance for CO2 but insignificant for ANS. Specifically, the results from the CO2 specification suggests that, all other variables constant, an increase in the number of people by one causes CO2 emissions per capita to increase by 0.00000000816 kilotons (0.00000816 metric tons). This result is also consistent with findings of Muhammad et al. (2011) and Hossain (2012). Despite the insignificance of total population for ANS, it can be interpreted that, all other variables held constant, an increase in the number of people by one causes ANS to increase by 0.0000000135%. The study by Abdulia and Ramsecke (2009) is in consonance with the findings of this study as a positive linkage is established between population density and ANS (a proxy for environmental sustainability).

Thus, it can be concluded that total population tends to enhance environmental sustainability as measured by ANS while at the same time, destroys the environment through CO2 emissions. Hence, the net effect of would depend on whether the gains generated from ANS outweigh the harmful effects generated through per capita CO2 emissions.

4.6.2 Sub-Regional Dummies: The Impact of the Variables In The Sub-Regional Blocks.

The second regression model examines the extent of variations in per capita CO₂ emissions and ANS across the four sub-regional blocs in SSA; namely Southern African Development Community (SADC), East African Community (EAC), Economic Community of West African States (ECOWAS) and the Central African Economic and Monetary Community (CEMAC). To this end, four (4) dummies are used and constructed for SADC, EAC, CEMAC and ECOWAS. For the purpose of analysis, ECOWAS is used as the reference category. The result of the extent of variations in per capita CO₂ emissions and ANS across the four sub-regional blocs in SSA is reported as regression 2 in Tables 4.4 and 4.5 respectively.

It is clear that, all the sub-regional dummies are negative and statistically significant at 1% for per capita CO₂ emissions. This supports the argument that the possibility of economic growth, trade openness, FDI and total population jointly reducing per capita CO₂ emissions in SADC, CEMAC and EAC countries is high compared to their counterparts within ECOWAS. The severity of this effect is however more pronounced in EAC, followed by CEMAC and SADC. This order in the reduction response for the sub-regional blocks can be attributed to the total amount of CO₂/P emissions contributed by each regional block (see Table 4.2). From table 4.2 it can be observed that SADC is the largest contributor of CO₂/P emissions followed by CEMAC, EAC and then ECOWAS. This goes to reason that, all things being equal, EAC will respond quickly in reducing emissions followed by CEMAC then SADC.

On the other hand, the results from ANS shows that the coefficients of CEMAC and SADC are positive and significant at 5% and 1% respectively but countries belonging to the EAC is insignificant though its directional effect is negative. It can therefore be concluded that, compared to ECOWAS the explanatory variables (economic growth, trade openness, FDI and total population) have a higher probability of jointly increasing environmental sustainability (ANS) in CEMAC and SADC. This effect is however more pronounced in SADC than in CEMAC. This is not surprising as SADC contributes largest and positively towards ANS compared to the other sub-regional blocks (see table 4.2). The results of this study is however in contradiction to the study of Hyun-Hoon Lee et al. (2005) where a dummy variable called ASIA-PACIFIC which takes 1 for the 32 countries in the Asian and Pacific region and 0 otherwise was included in the study. The regression results for the overall measure of environmental sustainability revealed that the coefficient for the Asia-Pacific dummy has a negative sign, but is not statistically significant.

From the foregoing, it can be concluded that compared to ECOWAS, the combined effect of all the variables in the sub-regional blocks unambiguously improves the environment except for EAC. Whereas there is reductions in per capita CO₂ emissions in EAC, sustainability is seen to be worsened compared to ECOWAS. This means that the net effect will depend on relative gains from the per capita CO₂ reductions compared to the fall in sustainability.

4.6.3 Interactions: Assessing the Possibility of the EKC Relationship in the Sub-Regional Blocks.

In this regression model, the sub-regional dummies are interacted with economic growth and its squared to determine the existence or otherwise of the EKC hypothesis in the sub-regional blocks for per capita CO₂ emissions and ANS. As in the second model, ECOWAS is used as a reference category. From the results of CO₂, all the interacted variables are significant at 1%. It can also be easily observed that all the interacted variables of the regional dummies with economic growth are negative but positive for the interaction with economic growth squared.

This means that compared to countries in the ECOWAS region, all the sub-regional blocks in SSA, during the initial stages of per capita income, experiences reductions in per capita CO₂ emissions to a given threshold after which further economic activities reverses it to an increasing trend. Hence a U-shaped relationship is achieved between economic growth and per capita CO₂ emissions for EAC, CEMAC and SADC; hence not conforming to the EKC hypothesis. The plausible reason for the non-existence of an EKC hypothesis for per capita CO₂/P emissions could be that, as the various economies in the sub-regional blocks set out on their growth path, environmental concerns are initially prioritised such that income per capita translate into decreases in per capita CO₂ emissions. However, as economic activities improves, environmental concerns are compromised to the extent that there is a rising trend in per capita CO₂ emissions. The study therefore predicts that for the sub-regional blocks, CO₂ emissions would be on the increase even as their economies expands beyond a threshold level. This could be attributed to the fact that, as the economy expands beyond a threshold level, the income

effect would not be strong enough to cause a decline in CO₂ emissions in the sub-regional blocks.

The findings of this study are in consonance with the findings of Abimbola et al. (2010) and O.A. Olusegun (2009) where they estimated an EKC model for CO₂ for a time series data set in Nigeria finding a U- shaped relationship between per capita GDP and CO₂ emissions per capita. The same findings are also in consonance with the findings of J.A. Omojolaibi (2010) who found non-existence of the EKC for individual countries namely Ghana, Nigeria and Sierra Leone using a panel data methodology to estimate the relationship between carbon emissions and GDP.

On the other hand, the ANS results reported all the interacted variables apart from the SADC to be insignificant and shows the existence of the EKC hypothesis since the interacted lagged economic growth and its squared are positive and negative respectively for EAC and CEMAC. The interacted variable of SADC with the lagged economic growth and its squared are also found to be significant at 10%. The validity of the EKC hypothesis is also proven in SADC by revealing a positive and negative coefficients for the interaction of lagged economic growth and its squared respectively. More specifically, an increase (decrease) in lagged economic growth by a dollar results in an increase (decrease) in ANS by 0.0479 but as economic activities increases within the sub-region, there is a negative influence on ANS of -0.0000402 all things being equal. The implication of this is that compared with countries under ECOWAS, those under SADC experience a higher probability of having an inverted U-shaped relationship between economic growth and ANS. This results can be explained that, countries in SADC either accumulate less capital against adjustments for consumption and degradation of natural

capital or vice versa, as their economy expands beyond a given threshold compared to their EOWAS counterparts.

4.7 Concluding Remarks

The data for estimation favours fixed effects model which is a requirement for the use of the system GMM estimation procedure. The other diagnostic tests: autocorrelation, heteroscedasticity, and overidentifying restrictions yield results that are favourable for the use of the system GMM estimation technique.

The estimation results show that the EKC hypothesis holds for both per capita CO₂ emissions and ANS in SSA. Trade and FDI are also found to have unambiguous worsening impact on the environment irrespective of which measure is used. However, the net effect of total population would depend on whether the gains generated from ANS outweigh the harmful effects generated through per capita CO₂ emissions.

Furthermore, compared to ECOWAS, the possibility of the joint effect of all the variables in the sub-regional blocks having an unambiguous improvement on the environment is high for CEMAC and SADC but not in EAC. Whereas there is reductions in per capita CO₂ emissions in EAC, sustainability is seen to be worsened compared to ECOWAS. This means that for EAC, the net effect will depend on the relative gains from the per capita CO₂ reductions compared to the fall in sustainability. Finally, compared to ECOWAS, the EKC hypothesis is confirmed for per capita CO₂ emissions in the other regional blocks. Although the EKC hypothesis is also valid in all the regional blocks for ANS, it is only significant for SADC.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS.

5.0 Introduction

This chapter summarizes and concludes the study by presenting a summary of the main findings from the study and further drawing some recommendations for policy and further research. The next section is dedicated to the summary and conclusions drawn from the findings in the study. Section 5.2 gives recommendations for policy based on the empirical results of this study. The last section discusses the limitations of the study and suggests areas for future research.

5.1 Summary and Conclusions of the study.

After the publication of the Brundtland commission report in 1987, the concept of economic development has received a much closer attention. Since then, most countries have been involved in charting policies to achieve sustainable development by considering the environmental effects of development activities. For the sub-Saharan Africa region, the drive for pursuing growth is most crucial given its current poor stance. Most countries in the region are implementing various policies aimed at improving their economies by permitting more trade openness and raising the attractiveness of the economy to foreign direct investment Morris (2008). As much as there is considerable need and desirability for trade, foreign direct investment and growth, questions still remain concerning their effects sustainable development. Although much empirical studies have explored the environmental effects of globalization (trade and FDI) and economic growth, very little is known about SSA. Additionally, most of these studies

have been criticized for lacking an environmentally adjusted income measure, or an indicator for environmental sustainability as they have concentrated on pollution. On this premise, this study sought to provide current evidence on this issue by investigating the environmental effects of economic growth, trade and FDI in SSA by providing answers to the following research questions:

- Is there a relationship between economic growth, trade, FDI flows and environmental quality and sustainability?
- Does the EKC actually exist for CO₂ emissions and Adjusted Net Savings?
- Do the possible differences between the sub-regional blocks in SSA indicate any systematic dynamics regarding the relationship between economic growth, FDI, trade and the environment?

In order to empirically address the above research questions, the model for estimation is specified from a dynamic panel framework based on the predictions of the Environmental Kuznets Curve (EKC) Hypothesis, and estimated using the system GMM estimation procedure. This estimation procedure is adopted due to its strength in overcoming estimation problems that comes with other techniques such as Ordinary Least Squares (OLS), Instrumental Variables (IV) and the traditional panel estimations.

The estimation results from this study show a positive relationship between economic growth, trade openness, FDI and environmental quality (CO₂/P). On the other hand, these variables (economic growth, trade openness and FDI) had an inverse relationship with environmental sustainability (ANS) for SSA. This results implies that trade and FDI have an unambiguous worsening impact on the environment irrespective of which measure is used. In responding to the second objective, the results showed evidence of an EKC

relationship for both environmental quality and sustainability in SSA. Specifically, per capita CO₂ emissions and ANS have a decline effect as the SSA economy expands beyond a threshold level. This suggests that as growth improves in the sub-region, there is a reducing effect on per capita CO₂ emissions but sustainability of the environment falls.

For the last objective of the study, the overall performance of the variables in the sub-regional blocks namely Southern African Development Community (SADC), East African Community (EAC), Economic Community of West African States (ECOWAS) and the Central African Economic and Monetary Community (CEMAC) is first investigated followed by a verification of whether or not the EKC hypothesis exist in the sub-regional blocks. The results revealed that, compared to ECOWAS, the possibility of the joint effect of all the variables in the sub-regional blocks having an unambiguous improvement on the environment is high for CEMAC and SADC but not in EAC. For EAC, whereas there is reductions in per capita CO₂ emissions, sustainability is seen to be worsening compared to ECOWAS. Finally, the EKC hypothesis is confirmed for per capita CO₂ emissions in the other regional blocks compared to ECOWAS. However, with respect to ANS, comparing with ECOWAS, all the regional blocks showed evidence of an EKC hypothesis but only significant for SADC.

5.2 Recommendations for Policy.

From the results of the study, some interesting implications for policy and further research could be made.

To begin with, the study finds a positive relationship between income per capita and per capita CO₂ emissions as well as ANS. This implies that the net effect of income per capita on the environment is ambiguous since it supports environmental sustainability as measured by ANS but worsens its quality as measured by per capita CO₂ emissions. The study therefore recommends that policy makers within the region strengthen their environmental norms and regulations through a strong environmental administration in their effort to implement growth stimulating policies.

Secondly both trade openness and FDI were revealed to have an unambiguous worsening effect on the environment. This finding can be linked to the “race to the bottom” hypothesis which posits that international trade and investment create downward pressure on environmental regulations in host countries. To remedy the environmental effects, the study recommends that countries in SSA must look at policies that focus on reducing the volumes of trade and FDI flows by better enforcing their own environmental codes and regulations through a strong environmental administration.

In addition, notwithstanding the adverse effect of trade openness and FDI inflows, policy makers in the region should promote technological policies that encourage cost-effective green innovations which can translate into huge economic benefits while being environmentally friendly. Another policy area that can be explored is the use of market-based instruments such as price and other economic incentives to regulate trade and FDI inflows. This policy option has the potential of achieving the same target as the command-and-control approach by raising barriers to liberalization but with lower cost.

With respect to the existence or otherwise of the EKC hypothesis for SSA, the study found support for an EKC relationship for both per capita CO₂ emissions and ANS implying that the overall effect on the environment is unclear. Whereas increases in per capita income have a declining effect on per capita CO₂ emissions after a given threshold, environmental sustainability proxied by ANS worsens with continuous increase in income per capita. Since economic growth is crucial for SSA and has a reducing effect on pollution, the study therefore recommends that policies that aim at encouraging economic growth while investing in capital formation be implemented across the sub region in order to mitigate against future demand on consumption and natural resource degradation that may lead to declines in future values of ANS. Furthermore, policies that focus on providing regulations for how companies within the resource extraction sector should manage a pollution-creating commercial process must be seriously implemented.

The results of the study also found that, compared to ECOWAS, the possibility of the joint effect of all the variables in the sub-regional blocks having an unambiguous improvement on the environment is high for CEMAC and SADC. It is therefore recommended that new technologies that promote green innovations and have the potential of boosting growth, trade and FDI flows while being environmentally friendly be implemented in the sub-regional blocks.

In conclusion, it is also necessary for both government and stakeholders to provide adequate resources for existing environmental agencies and their personnel across the region to ensure effective coordination and measuring of the extent of the effect of the above policies. In addition, due to the diversity of the environment, any policy designed

to ensure its quality and or sustainability should be comprehensive enough to include all dynamics of other factors. Also these policies must reflect the preference of the population so as to maximize the balance between economic development and environmental protection. Encouraging and securing public participation in this area are therefore significant components.

5.3 Limitations of the Study and Areas for Further Research

The major drawback of this study is that it did not look at other dimensions of environmental quality such as an indicator that captures environmental impacts of several types indirectly like energy consumption as well biochemical oxygen demand (BOD) an indicator for water quality and other air pollutants such as emissions of chlorofluorocarbons (CFCs). Hence future research on the relationship between environment, income and globalization should aim to be as comprehensive as possible by considering more environmental indicators.

Other areas for future research that would also make meaningful contributions to the existing literature includes considering a comparison of the various developing regions of the world and country-specific analysis of the relationship between globalization and the environment for the countries used in this study.

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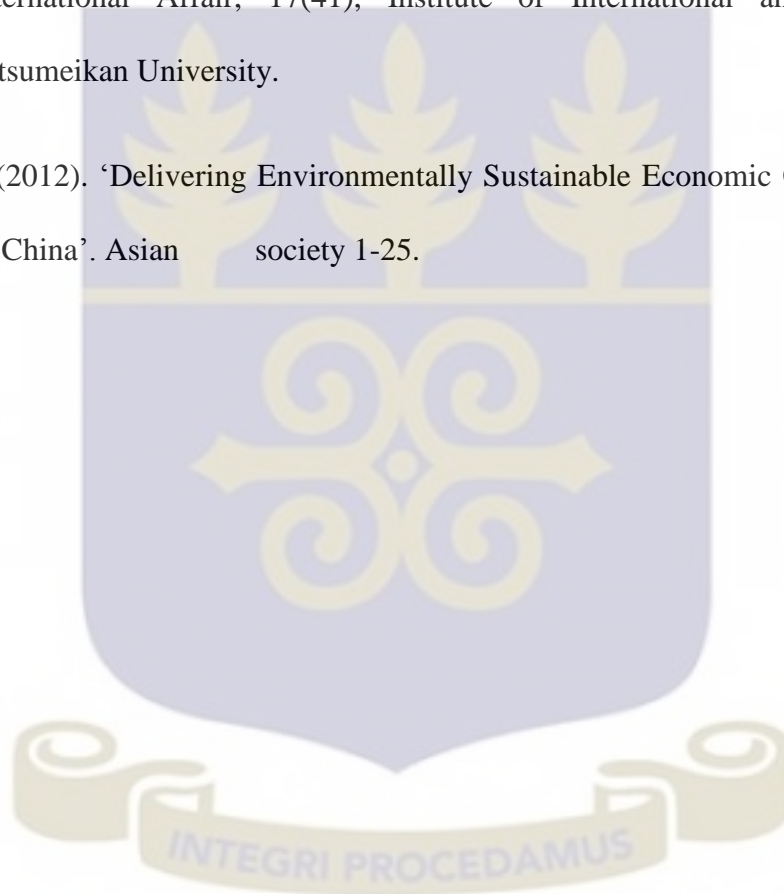
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APPENDIX

Appendix I: List of the 37 SSA countries in the study by region

| East Africa | Middle Africa | Southern Africa | Western Africa |
|--------------------|----------------------|------------------------|-----------------------|
| Burundi | Angola | Botswana | Benin |
| Comoros | Cameroon | Namibia | Burkina Faso |
| Ethiopia | Central African rep. | South Africa | Cote d'Ivoire |
| Kenya | Chad | Swaziland | Gambia, The |
| Madagascar | Congo, Dem. Rep. | Zambia | Ghana |
| Malawi | Congo, Rep. | | Guinea |
| Mauritius | Equatorial Guinea | | Mali |
| Mozambique | Gabon | | Niger |
| Rwanda | Sudan | | Nigeria |
| Tanzania | | | Senegal |
| Uganda | | | Sierra Leone |
| | | | Togo |

Source: Based on United Nation's Classification of Countries