TRADE-ENVIRONMENT NEXUS: AN EMPIRICAL EXAMINATION OF SUB-SAHARAN AFRICA AND EAST ASIA

BY

MATILDA TSEKPOKUMAH

(10406447)

University of Ghana

INTEGRI PROCEDAMUS

THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF MPHIL ECONOMICS DEGREE

JULY, 2019

DECLARATION

This is to certify that this thesis is the result of research undertaken by Matilda Tsekpokumah towards the award of Master of Philosophy Degree in Economics at the Department of Economics, University of Ghana, Legon.

…………………………………………………..

MATILDA TSEKPOKUMAH

(10406447)

20/07/2020

…………………………

Date

Supervisors

……………………………………………….

DR. FESTUS EBO TURKSON

11/08/2020

………………………………….

Date

……………………………………………

DR. ABEL FUMEY

30 /07/2020

………………………………….

Date

ABSTRACT

The importance of trade to economies cannot be overemphasized, albeit the associated environmental implications. East Asia houses the largest greenhouse emitting country in the world whiles Africa's economy is highly dependent on trade but literature in these two regions is lacking. To examine the environmental effect of trade for these two regions, this current study employed the Generalized Method of Moments on a panel of forty-seven SSA countries and seven East Asian countries for a period of 34 years. The study found trade openness to increase the emission of carbon dioxide but played no significant role in the emission of nitrous oxide and methane. On average, the study finds trade to be beneficial to the environment of SSA and East Asian countries and therefore ongoing trade liberalization should be fostered.

DEDICATION

This thesis is dedicated to my foremost dedicated to the Almighty God, to my supportive mom- Zenabu Issah- to my siblings and all my amazing friends and family for their care, love and sacrifices throughout this study.

ACKNOWLEDGEMENT

I am grateful to God Almighty for His continued blessing and grace that has kept me going all these years. My warmest appreciation to my mother; Zenabu Issah for all the encouragement, understanding and support in my academic pursuit. I cannot be thankful enough to Professor Alexander Bilson Darku for his expert advice, encouragement, financial support and fatherly love towards this end. I am indebted to my supervisors; Dr. Festus Ebo Turkson and Dr. Abel Fumey for their dedication, time, guidance and suggestions that brought this work to light. To Mr. Forster Junior Shitsi and Miss Madleen Madina Frazer, I cannot thank you enough. May the Good Lord bless and replenish everything you lost in encouraging and being a solid pillar through this study.

TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

Page

LIST OF ACRONYMS

BOD	Biochemical Oxygen Demand
CH_4	Methane
CO_2	Carbon Dioxide
CPI	Corruption Perception Index
DF	Dickey-Fuller
EKC	The Environmental Kuznets Curve
EPA	Environmental Protection Agency
ER	Environmental Regulation and Institutional Arrangement
FAOSTAT	Food and Agriculture Organization Statistical Database (United Nations)
FDI	Foreign Direct Investment
FE	Fixed Effects
FEH	Factor Endowment Hypothesis
FMOLS	Fully Modified OLS
FT	Fisher-Type
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GLS	Generalized Least Squares
GMM	General Method of Moments
HENC	Heterogeneous Non-Causality
HNC	Homogeneous Non-Causality
H-O	Hecksher-Ohlin
IEA	International Energy Agency
IPS	Im-Pesaran-Shin
IV	Instrumental Variable
Klr	Capital-Labour Ratio
LDCs	Less Developed Countries
LM	Lagrange Multiplier
N_2O	Nitrogen Oxide

NAFTA	North American Free Trade Agreement
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
PGPLS	Population Growth per Land Size
PH	Porter Hypothesis
PHH	Pollution Haven Hypothesis
PMG	Pooled Mean Group
POPs	Persistent Organic Pollutants
PPM	PART PER MILLION
R&D	Research and Development
RE	Random Effects
rklr	Relative Capita Labour Ratio
rRYPC	Relative Real GDP Per Capita
RYPC	Real Income Per Capita
SDGs	Sustainable Development Goals
SO2	Sulphur dioxide
SSA	Sub-Saharan Africa
TOP	Trade Openness
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNFCCC	United Nations Framework Convention on Climate Change
VAR	Vector Autoregression
WDI	World Development Indicator
WTO	World Trade Organization

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

In recent years, the issue on the relationship between trade and environment has become of policy and theoretical concern. For the first time, the Sustainable Development Goals (SDGs) has formed an independent charter that addresses issues concerning aquatic life and the ecosystem (UNCTAD, 2016). The debate on the role of international trade on the environment has attracted more attention than the Daniel Hamermesh's paper; "Beauty pays: why attractive people are more successful" (Antweiler *et al*., 2001). The universal objective is to address and to curb to the barest minimum the problems of emissions. In this end, summits, including the Rio Summit in 1992 have been held to draw awareness to the impact of globalization on the environment after the United Nations Stockholm Conference on Human Environment in 1972. There also came the summit for sustainable development held in Johannesburg, 2002 (Seyfang & Jordan, 2002). The United Nations (UN) after these mega-conferences also held more of such summits including the 2019 one-planet summit, all in the quest of addressing environmental issues. International trade plays a very significant role in environmental outcomes on the one hand and on the other environmental regulations and policy affect the pattern of trade.

The discussion on the interdependence between trade and the environment has produced different opinions between trade theorists and environmental activists. While some argue that trade is an essential source of employment creation and economic development (Frankel *et al*., 2002; Muhammad, Adan & Kumar, 2013), others find it destructive to the environment (McCarney & Adamowicz, 2006; Mangi et al., 2008). International trade has the potential of exerting a strong influence on the economic growth of a country. The World Bank (2019) reports that, with the opening up of economies, emerging and developing countries such as India and China, have grown over the years.

International trade is essentially the movement of goods and services from one country to the other. Specifically, the transformation of an economy's technology, commodities and inputs which transcends the market of a country's output, and facilitates welfare is International trade (Samuelson, 1973). Countries engage in international trade partly to compensate for what they do not produce. The argument that no one country is self-sufficient gives apparent support to the importance of cross-border trade. No country in the world can be economically independent without a fall in its economic growth (Vijayasri, 2013). Even the poorest of economies has something significant to offer, usually natural resources, in the globally competitive and industrialized economies or richest countries buy raw materials for their industries from the poorest countries.

The essence of international trade is studied greatly, and there is little dispute about the significance of cross-border trade for all the countries in the world. Antweiler *et al.* (2001) and Frankel *et al*. (2002) have found that free trade is good for the environment. International trade provides an atmosphere for developing countries to borrow at a very low rate from the international market, which "closeness" does not offer. It enhances employment, economic development and improves individual welfare by making available in a country varying goods and services for consumption and production purposes.

Opponents of International trade, however, argue that trade liberalization is crippling to infant industries since global trade introduces cheaper goods on the market where indigenous infant industries are unable to compete with in terms of prices (Lopez, 1997; Cole *et al*., 1998).

International trade is detrimental to countries that sell just primary goods and buy manufactured goods; which are characteristic of developing countries and thus the low standard of living in these countries. Imports of harmful drugs such as opium into China, as a result of trade liberalization, could be injurious to the health of a nation. The burning of fossil fuels in production as a result of increased trade increases the level of concentration of harmful gases in the atmosphere (Managi *et al*., 2009). Through international trade, economic disturbance in one country becomes a problem of other countries. International trade also sometimes leads to fast exhaustion of non-renewable resources that are found particularly in developing countries.

International trade between Africa, specifically Sub-Saharan Africa (SSA) and Asia specifically East Asia, has been on a rapid rise making Asia the biggest trading partner to Africa. SSA is heavily dependent on imported goods and thus accounts for why Africa lost its status as a net exporter of agricultural products during the early 1980s (FAOSTAT, 2011). Economically, SSA has performed poorly over the decade on the global trade market (Babatunde & Egwaikhide, 2010; Harvey & Sedegah, 2011; Ayodotun & Farayibi, 2016). On the contrary, the growth of trading partners like China over the past decade has ensured high demand and prices of primary commodities such as minerals and oil, which has critically benefited SSA countries. Trade between China and Africa grew significantly to $160billion in 2012 from $2billion in 1991 (Cisse, 2012). International trade is a vital part of SSA economies with the value of exports in 2011 equaling about 34% of the region's aggregate GDP (World Bank, 2013)

Theoretically, significant strides have been made to explain and indicate the nexus between trade and environment. These includes the Factor Endowment Hypothesis (FEH) and the Pollution Haven Hypothesis (PHH). On the one hand the PHH argues that countries with weak environmental regulations are exposed highly to pollution-intensive production. This explains the high extent of emissions in developing countries relative to developed countries who have stricter environmental regulation. The FEH, on the other hand, argues that relatively capital-intensive and well-endowed technological developed countries would attract more pollution-intensive industries and therefore get dirtier with trade and vice versa. However, empirical evidence of these claims has not been forthcoming (Antweiler *et al*., 2001) and conclusive. For instance, Tobey (1990) and Grossman *et al*. (1993) have shown that international trade is determined by factor endowment rather than effective abatement costs related to pollution. Likewise, research finds more evidence for the factor endowment theory rather than the pollution haven hypothesis.

The implication is that trade is not necessarily affected by the environment and vice versa. Antweiler *et al*., (2001) and Frankel *et al*. (2002) have found however, positive implications of trade on the environment. Also, proponents of trade liberalization are of the view that environmental quality can be classified as a normal good, hence, income gains from trade should promote society's demands for quality environment or environmental standards. Increased demands for stricter standards of environment promotes cleaner and environmentally friendly techniques of production (Gavrilescu, 2004). Opponents however, stipulate that pollution would continue to assume an increasing trend if the methods of production do not change with increasing trade. Because trade increases the scale of economic activities. over, if environmental quality is a normal good, then less developed countries will adopt relatively low environmental regulations and vice versa (Baek, Cho, & Koo, 2009).

The environmental impact of trade is composed of three: effect on the scale of production in the economy, on production techniques, and on industrial compositions. (Copeland & Taylor, 2003; Antweiler *et al*., 2001; WTO, 2009).

1.2 Statement of the Problem

Five (5) of the seventeen (17) SDG's are geared towards the environment and how best it can be protected with particular emphasis on goal 13 which calls for an urgent need to combat climate change and its impacts. This goes to tell how much there is a need to focus more attention on trade-induced environmental relations, especially in developing and emerging economies.

The concentration of carbon dioxide in the world's atmosphere hit a world high of 412.60 parts per million (ppm) on May 14, 2018, as reported by an online source: CO_2.earth. The 2009 United Nations Climate Change Conference in Copenhagen saw a universal consensus not to warm the world's temperature over 2 degrees Celsius (2°C) from pre-industrial levels (ranging between 200 - 270 ppm). However, in 2012 the World Bank warned that the world was on a track for a 4°C warmer world marked by dangerous heat waves, diminishing global food stocks, loss of ecosystems' biodiversity, and alarming sea level rise. To understand this 4°C rise in temperatures, as of 2015, the temperature has only risen by 0.8°C; nonetheless, we are already facing extreme drought, excessive glacial melting, loss of sea lives and increasing acid in oceans.

International trade plays a vital role in consumption and production since it helps solve the issue of unequal distribution of the world's resources. Africa contributes around 2.4 per cent of global trade with sub-Saharan Africa, contributing about just 1.7 per cent (Schmeig, 2016) and continuously dependent on imported goods. Trade between Africa and Asia has been on the rise in recent time. Does this recent rise in trade cause for alarm, does these mean countries should tighten their trade regulations and is trade really detrimental to the environment? The answer is not apparent.

The recent rate of environmental deterioration and loss of natural resource, especially in developing countries, has become a fundamental issue of concern for economists (Antweiler *et al*., 2001). In East Asia, China is ranked highest in carbon dioxide (CO_2), accounting for about 21.5% of the world's total followed by India which is the world third largest emitter (Jayanthakumaran *et al*., 2011). The public opinion is that developed countries improve their environment quality through openness while developing countries lose when it comes to the environment from trade (Chang, 2012). Climate experts have indicated that SSA is among the most vulnerable regions since they are heavily dependent on rainfall enhanced agriculture. Some also argue that Africa has no business with climate change and emissions. However, there is evidence of increase global emission of CO_2 over time. For the period 2001-2008 Worldbank database reported a rate of 2.17% showing a 0.02% increase from its 1991-2000 rate of 2.15% and 1.78% in 1971-1980. Juxtaposing these figures with that of East Asia and the Pacific who contributed about 30.9% of the world's total in the period 2001-2008 represents the relatively low contribution to the world's total emission by the African continent. However, since the world is a global village, the deleterious effects are borne by all.

Pollution transcends boundaries, for instance, in the event of cross-border spread of acid rain; therefore, there is a need to pay more attention to the environmental implications of cross-border trade especially between the most-polluter regions and the most vulnerable regions. Empirical shreds of evidence are hard to come by in this area, hence the need for the current study with particular emphasis on SSA and East Asia.

Research on the trade-environment nexus has been inconclusive on its findings. The environmental effect of trade openness is challenging to predict. It has been stipulated to either trigger displacement of peasants and thereby environmental degradation or lead to the improvement in the livelihood of individuals since trade openness has the potential of improving the prices of agricultural products and therefore lessening degradation. This study is motivated by the fact that trade and its effect on environmental quality in transition economies and developing economies has not received much attention empirically. It is therefore imperative that a more detailed/comprehensive study using current dataset is conducted to justify the empirical importance of international trade on the environment.

It is therefore, imperative to protect the planet earth from deterioration through sustainable consumption and production through appropriate trade regulations and policies. As well as sustainably protecting and managing natural resources that these two regions possess and taking urgent action on environmental quality that this study is warranted.

1.3 Research Questions

This study seeks to provide answers to the following questions.

i. What is the role of trade on environmental quality?

ii. Is there a long run relationship between emissions and trade openness?

iii. Is there a causal relationship between trade and environmental quality?

1.4 Research Objectives

The primary objective of this study will be to examine the effect of trade on environmental quality for SSA and East Asia. The specific objectives of the study are as follows:

i. to examine the role of trade on environmental quality in both regions

ii. to assess the long run relationship between emissions and trade openness

iii. to examine the causal relationship between trade and the emissions.

1.5 Methodology and Data

The study makes use of the General Method of Moments (GMM) - considering system GMM- which was first developed by Holtz-Eakin *et al*. (1990) and later modified by Arellano & Bond (1991) & Arellano & Bover (1995). The study makes use of secondary data from the World Development Indicator (WDI) database. The study collects time series data for each country and puts these datasets into a panel framework of time series over a cross-section of countries. Hence, the study makes use of panel data analysis to examine the effect of trade on environmental quality. Selected variables for the study model are influenced by theory and empirical literature. International trade is measured by making use of import and export. Environmental quality is measured using emission data on Carbon dioxide (CO_2) and Nitrogen Oxide (N_2O) and Methane (CH_4) for the emerging and developing countries.

1.6 Significance of the Study

This study is foremost very significant because it is in accordance with the Sustainable development agenda on elaborating sufficient studies for the better understanding on the relationship between trade and environment for the promotion of development that is sustainable, especially in emerging and developing economies. In a nutshell, this study bridges the gap in the literature by employing updated data on emissions, controlling for FDI, incorporating N_2O as an environmental variable and finally critically assesses the causality between emissions and trade. These points are elaborated below;

The effect of international trade on the environment has received massive attention. In as much as this area of research has received varied attention, most of the works are concentrated within developed countries, China and other Asian countries or with OECD countries (Grossman & Kruger, 1991; Antweiler *et al*., (2001); Frankel, 2009; de Alwis,2015). There is very little empirical work dedicated to the trade environment nexus between East Asia and SSA. For instance, Bernard and Mandal (2016) examined the environmental impact of trade openness with focus on Asia, Latin America, Europe and Africa. This study, therefore, bridges that gap by assessing this impact solely on SSA and East Asia.

Currently, East Asia and Africa have become the best of friends in the world's global trade. Trade between SSA and East Asia, particularly China, has grown significantly since the 1990s (Jenkins *et al*. 2006). China is Africa's biggest trading partner in the global economy and continues to rise. Trade between China and Africa grew significantly to $160b in 2012 from $2billion in 1991 (Cisse, 2012). There is, therefore, a need for a comprehensive study with updated data on these two regions.

The inclusion of Nitrogen Oxide emissions to proxy for environmental quality is also of great significance because it results from agriculture practices, it is a local-pollutant, and its emission has increased in recent times (IEA, 2017). We, therefore, introduce Nitrous oxide as a proxy for environmental quality and therefore we may come to a different conclusion since most of the previous studies (Antweiler *et al*., 2001; Cole & Elliot, 2003; Managi *et al*., 2009; Jafari *et al*., 2017) and theory-developing studies were explicitly concentrated on carbon dioxide and Sulphur oxide emissions.

In this study, we build on previous studies foremost using updated data and focuses on this nexus in developing countries and the fast-developing region yet. Managi *et al*. (2009) argue that extended dataset affects the results and therefore, we extend the data coverage to the year 2018 and test whether we would come to similar conclusions. We build on previous studies by employing with updated data on CO_2, N_2O and CH_4.

This study also controls for FDI, which is a significant part of the regions under consideration; SSA, in particular, is highly dependent on FDI. Korves *et al*. (2011) stipulate that researchers agree that cross border trade breeds more than two-thirds of technological to trading nations, particularly developing economies. Trade promotes research and development (R&D) that in turn leads to the discovery of environmentally friendly production techniques, hence, reducing pollution *per capita*. In fact, FDI plays a salient role in the income of developing countries and none of the studies reviewed controlled for FDI. Therefore, we include this variable to assess how it would affect the conclusion on the trade-environment nexus.

Finally, the study will provide policymakers with adequate empirical evidence to make informed decisions on international trade agreements and also prompt for review or otherwise of environmental and trade regulations. Findings from the study will also provide the empirical basis for further researchers while heightening the need for a green environment. The study will also go a long way to promote growth and channel the path for sustainable development through environmentally friendly trade amongst countries. This will also serve as a reference for other countries to emulate.

1.7 Structure of Study

The study is organized into six main chapters. Chapter one deals with the general introduction to the study, which includes the background of the study, statement of the problem, research objectives, research questions and significance of the study. Chapter two reviews both the theoretical and the empirical literature on the trade-environment nexus. Chapter three is dedicated to the methodology, the empirical model and sources of data to be used by the study. Chapter four focuses on the estimation strategy and the methodology. Chapter five presents and discusses the empirical results of the study. Finally, chapter six provides the conclusion and recommendations of the study.

CHAPTER TWO

OVERVIEW OF EMISSIONS AND TRADE IN SSA AND EAST ASIA

2.0 Introduction

This chapter presents the overview of the trends of the trade-environment nexus in Sub-Saharan Africa and East Asia. This chapter is divided into two broad sections. The first section presents an overview of environment and trade patterns in the regions and the second section presents the graph as well as overview of environmental quality indicators.

Several efforts have been made globally in the quest to control the deterioration of the environment. To begin with, in 1963 the Vienna convention on civil liability for nuclear damage was enacted to provide a framework for establishing global regime widespread adherence by nuclear and non-nuclear states. Secondly the treaty on banning nuclear weapon tests in the atmosphere, in outer space and under water was enacted also in 1963 which prohibited the explosion of nuclear weapons in the atmosphere, in outer space, under water or in any other environmental media. Thirdly, to achieve nuclear safety worldwide, the convention on nuclear safety established and maintained effective decencies in nuclear installations against potential damage to the environment. Fourthly, a convention ratified in 1996 banned all nuclear test explosions which polluted the atmosphere.

In 1985, the Vienna Convention for the protection of the Ozone layer and the Montreal Protocol on substances that deplete the Ozone layer in 1985 which was amended in 2016 were adopted to protect the ozone layer. The United Framework Convention on Climate Change (1992), Kyoto Protocol (1997) and the Paris Agreement was also adopted to in 2016 to control climate change. The 2015 Paris agreement under the United Nations Framework Convention on climate Change (UNFCCC) was set as the first international agreement that quantify GHG mitigation. Furthermore, the agreement on cooperation on Marine oil pollution preparedness and response in the Artic in 2016 to protect marine, water and the environment as a whole. The Minamata convention on Mercury (2017) and Stockholm Convention on Persistent Organic Pollutants (POPs Convention, 2001) were all in quest to protect the environment.

2.1 Overview and trends of trade in SSA and East Asia

The debates on the impact of trade on environment are relevant bearing in mind the increasing volume of trade amongst the world's nations and the changes in environmental quality accompanied with it. Figure 2.1 and 2.2 below shows and upward trend of trade openness in both SSA and East Asia.

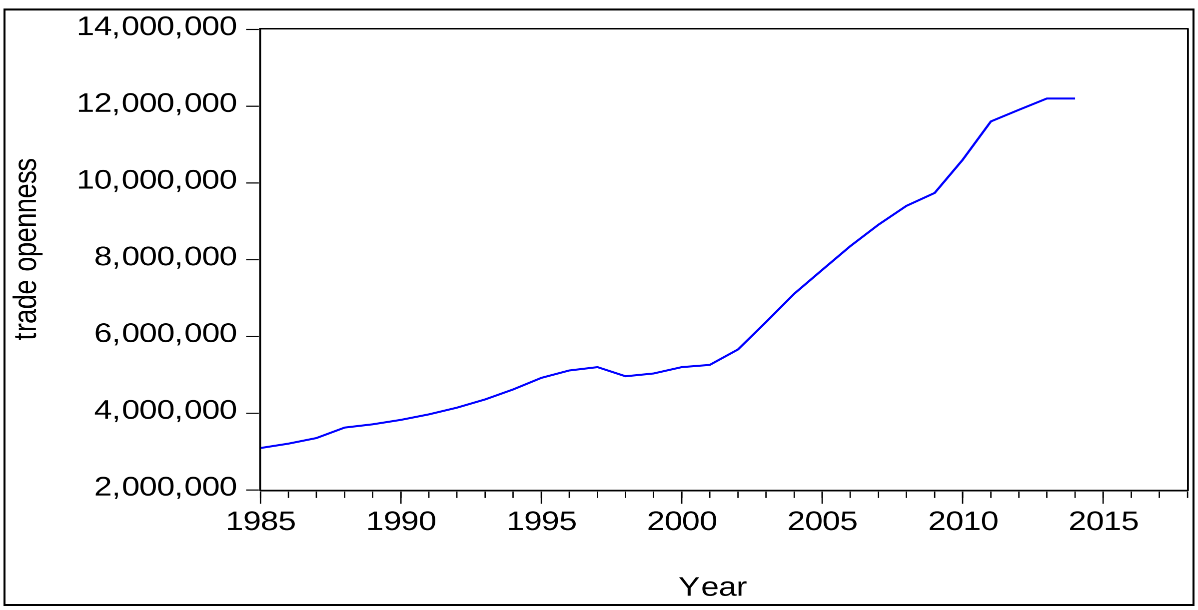

Figure 2.1: Total Trade openness for SSA (1985-2018)
Source: Author's Construction with data from Worldbank database

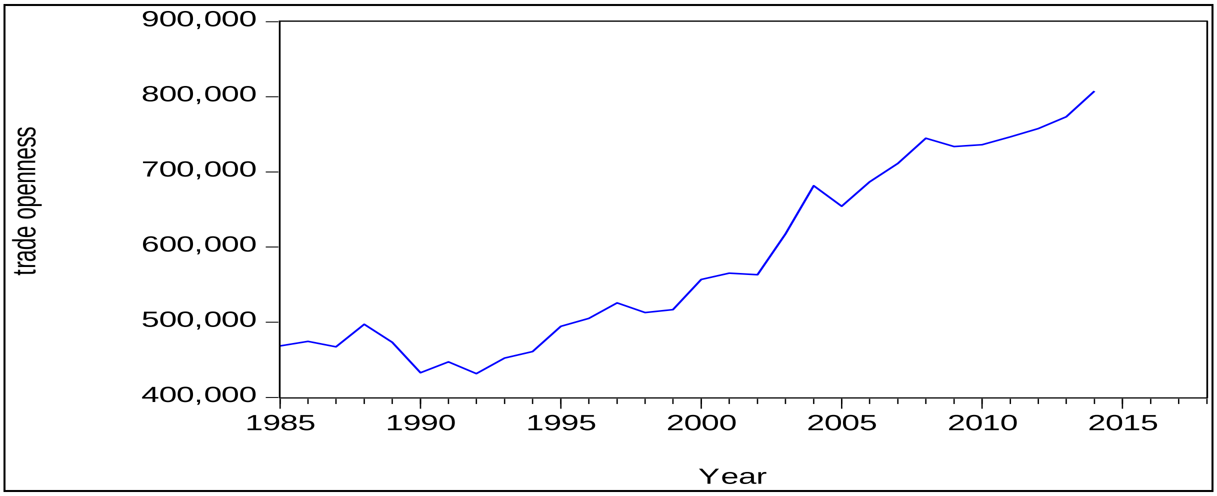

Figure 2.2: Total Trade openness for East Asia (1985-2018)
Source: Author's Construction with data from Worldbank database

2.2 Overview and trends of environmental quality indicators

Despite the increasing global efforts to lessen greenhouse gases emissions including the Kyoto Protocol, emissions in these regions continue to rise. Aggregate CO_2 emissions for SSA rose from 3,000,000kt in 1985 to about 13,0000,000kt in 2015 as depicted in Figure 2.3. In the same period the total methane and nitrous oxide emission by East Asia and SSA continued to rise steadily.

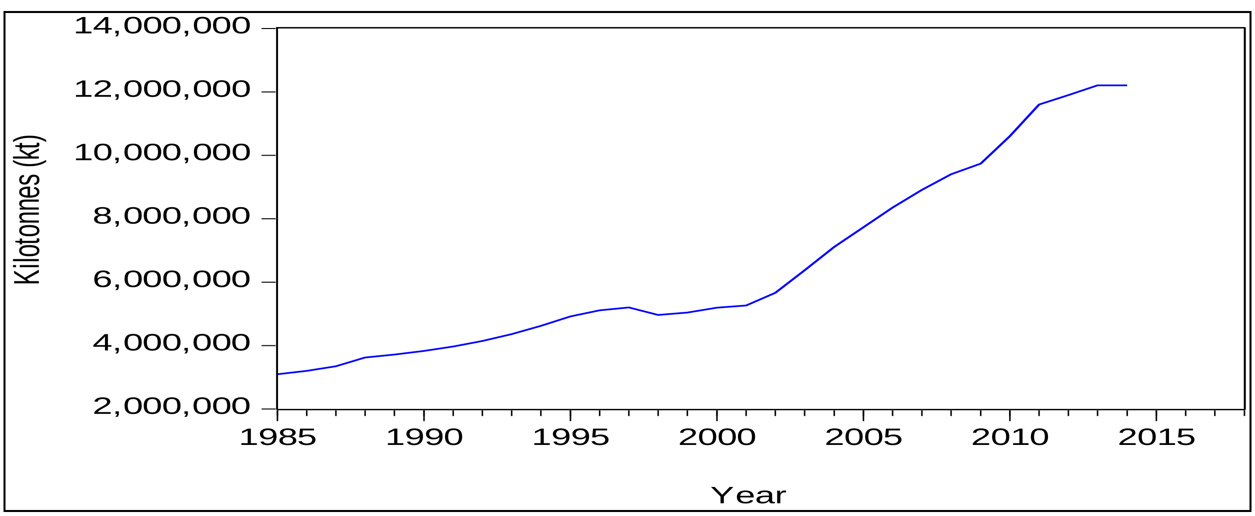

Figure 2.3: Total Emission of Carbon Dioxide for SSA (1985-2018)
Source: Author's Construction with data from Worldbank database

Fig 2.4 depicts the aggregate emissions of N20 for SSA constructed from the data. Nitrous oxide emissions saw an increase from 67,445kt in 2000 to 90,156kt in 2012. In the same way the emission of this gas in East Asia has increased over time; it increased from 7823kt in 2000 to 11815kt in 2012. The highest emitted in East Asia was in 2007 hitting a record high of 16326kt.

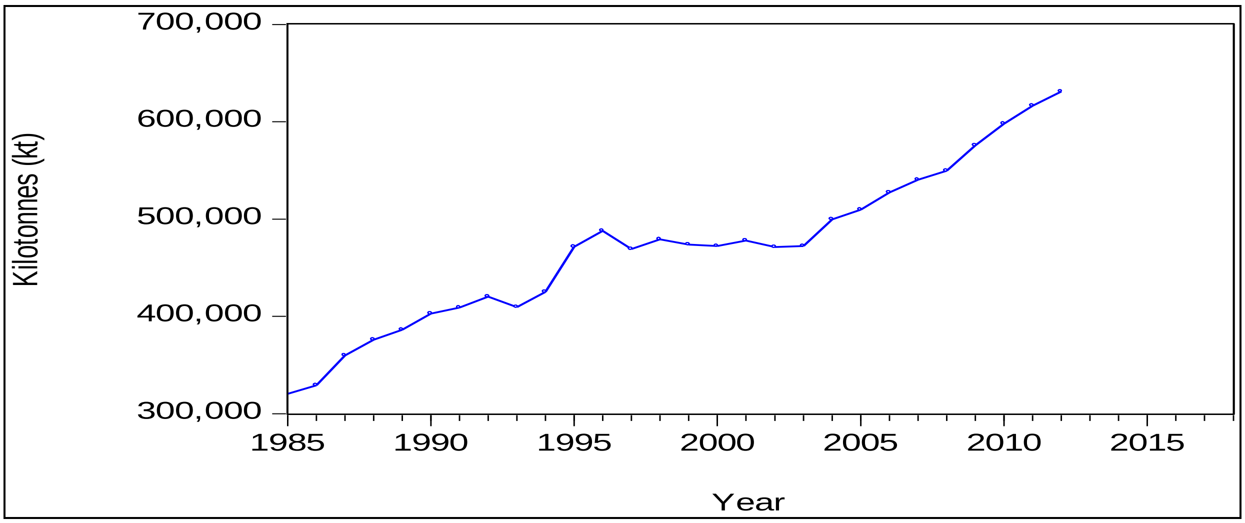

Figure 2.4: Total Emission of Nitrous Oxide for SSA (1985-2018)
Source: Author's Construction with data from Worldbank database

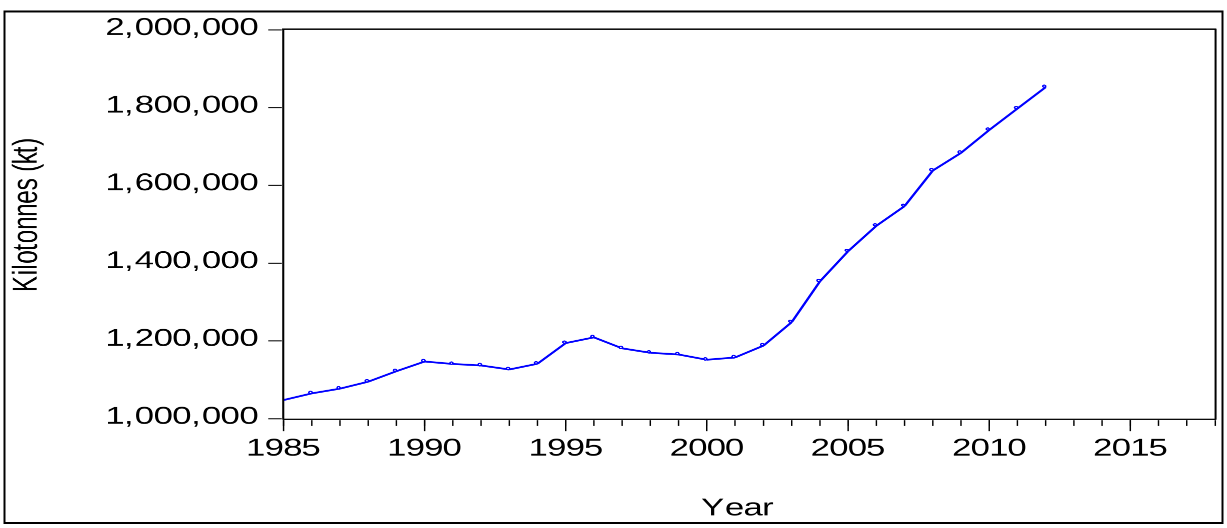

Figure 2.5: Total Emission of Methane for SSA (1985-2018)
Source: Author's Construction with data from Worldbank database

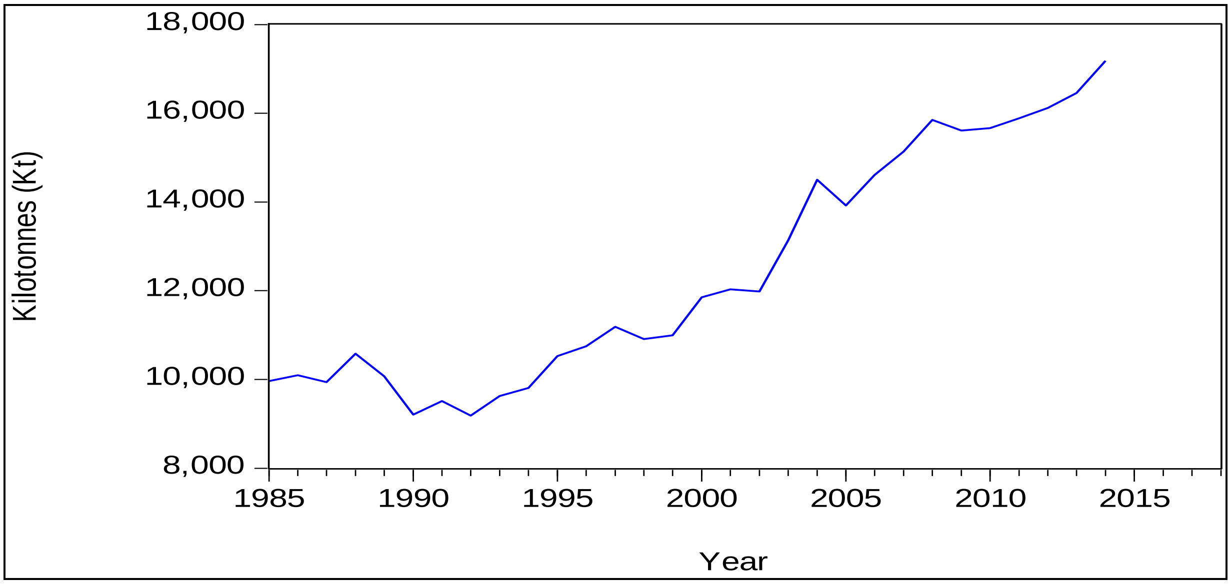

Figure 2.6: Total Emission of Carbon Dioxide for East Asia (1985-2018)
Source: Author's Construction with data from Worldbank database

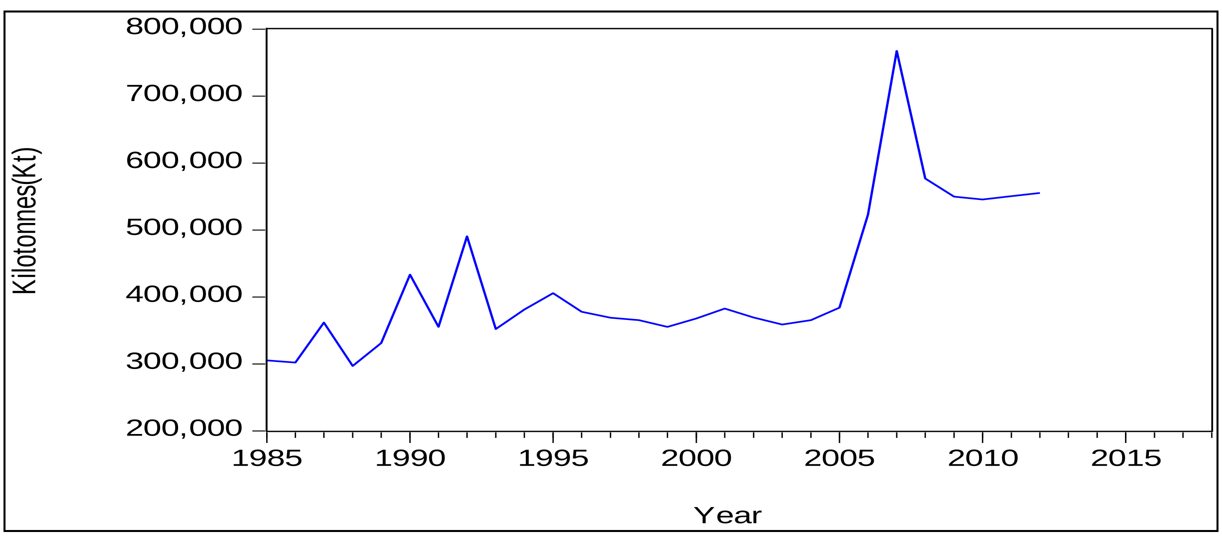

Figure 2.7: Total Emission of Nitrous Oxide for East Asia (1985-2018)
Source: Author's Construction with data from Worldbank database

Emission of methane in both regions also saw increases over the period of study. In Fig. 2.8 aggregate methane emissions have fluctuated over the years but has an increasing pattern. Aggregate of emissions depicted in Fig.2.5 above for SSA saw low levels in the early years but increases dramatically from 10008kt in 1980 to 22148kt in 2007. In SSA we saw emissions in 1985 increased from 1005000kt to 1850000kt in 2012.

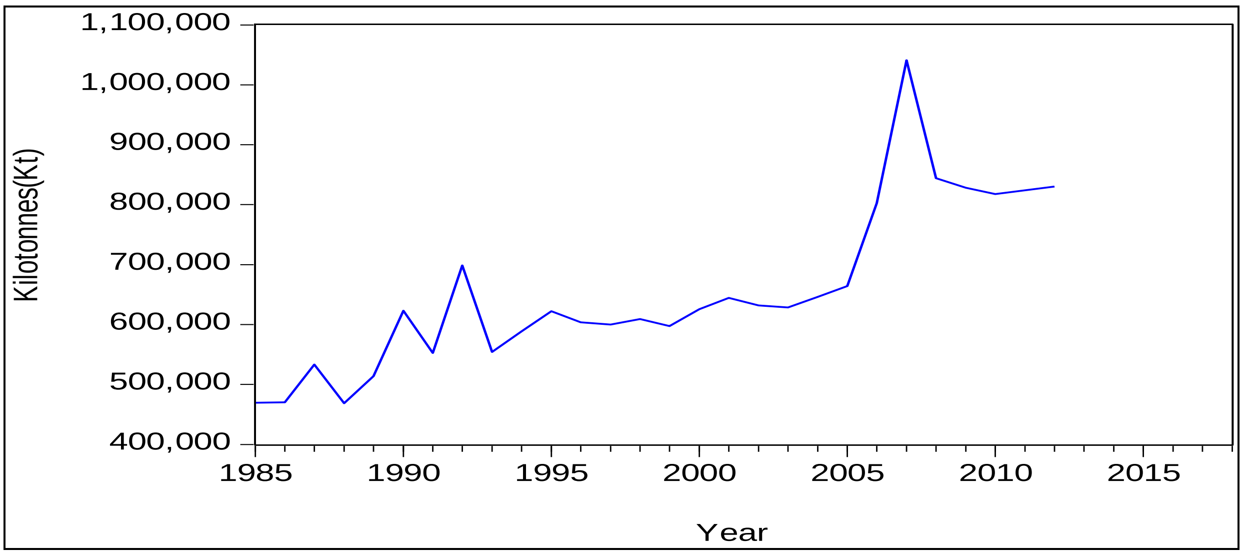

Figure 2.8: Total Emission of Methane for East Asia (1985-2018)
Source: Author's Construction with data from Worldbank database

CHAPTER THREE

LITERATURE REVIEW

3.0 Introduction

This chapter presents the review of relevant literature on trade and the environment. It entails two broad sections. The first part emphasizes the theoretical literature on trade and environment and the second part concentrates of the review of empirical studies on trade and the environment.

The trade-environment nexus has been extensively debated, both nationally and internationally. The argument on the environmental implications of trade has over the past decade and continues to attract global attention despite the extant studies over the years. This attention can be attributed to the mixed result reported by various studies, hence, promoting empirics beyond existing theories. This section of the study expounds the argument by providing a review of existing literature, both theoretical and empirical, with the aim of providing a conclusion to existing arguments and also for the purpose to provide empirical evidence for justifying the findings emanating from the current study.

3.1 Theoretical Review

The theoretical arguments on the trade-environment nexus are rooted in some fundamental theories developed since the early 1990s. Foremost among the theories that connects trade to the environment is the Environmental Kuznets Curve (EKC) followed by the Pollution Haven Hypothesis (PHH) and its alternate Factor Endowment Hypothesis (FEH) as well as the Porter

Hypothesis. This subsection draws on the EKC to explain the trade-environment relationship supported by PHH, FEH and the Porter Hypothesis.

3.1.1 The Environmental Kuznets Curve

The EKC after its adoption in the works of the World Bank (1992) has received extensive attention and respect by researchers, policymakers and academicians as hinted in Grossman and Krueger (1995). However, this hypothesis is rooted in the work of Simon Kuznets in 1950s on income inequality and economic development, which was presented at the 67th annual meeting of the American Economic Association in 1954. Kuznets (1955) postulated that the changing relationship between *per capita* income and income inequality followed an inverted U-shaped curve. Similarly, the environmental Kuznets curve hypotheses that there is a maximum for which economic growth could be beneficial to the environment beyond which could be detrimental. It stipulates that at initial stages of economic growth, there tend to be an increase pollution, attain a maximum and falls thereafter.

In economic theory, one of the major theories propounded in establishing and analyzing the environmental effect of economic growth is within the EKC. This curve, which establishes the environmental degradation and *per capita* income nexus with an inverted U-shape curve (Kijima *et al*., 2000) has its background from the Kuznets Curve. Kuznets (1955) propounded the EKC, which explains *per capita*-income inequality nexus within an economy. According to the EKC, income inequality initially increases with an increase in *per capita* income, attains a maximum and begins to fall, depicting a U-shaped relationship between growth and inequality gap. Yandle *et al*. (2002) explained this in the view of the increases in income inequality at the initial stages of growth. Thus, as economies begin to experience growth or as economic development proceeds (Stern, 2004), rich benefits more than the poor, hence widening the inequality gap. This process, however, continues to a point where the inequality peaks, and then begins to fall with subsequent growth, leading to a bridge in the inequality gap.

The idea of the EKC was first pitched by Grossman and Krueger (1991) in the early 1990s in postulating the environment-growth relationship in their inquiry on the impact of the North American Free Trade Agreement (NAFTA) on the environment. In their work, they argued that as income *per capita* increases, there are a lot of economic activities both human and physical that puts much pressure on the environment, hence increasing environmental degradation through various forms of emissions. However, beyond a particular growth stage, the environmental quality begins to improve with relatively less emissions than before. Implicitly, the EKC is a hypothesized nexus between various indicators of environmental quality and economic growth (Stern, 2004).

The concept also emerged in a background study by Shafik and Bandyopadhyay (1992) for the 1992 World Development Report. The World Bank's World Development Report of 1992 (IBRD, 1992) popularized the EKC theme, arguing that the static assumption about taste, technology, and environmental investment serves as the basis for the inevitable adverse effect of economic growth on the environment. The argument is that the demand for environmental quality increases with available resources for investment as income increases over time. This eventually results in a reduction in environmental degradation (improvements in the quality of the environment) as income *per capita* increases beyond a given threshold.

Beckerman (1992) expounded the argument positing that although there is degradation of the environment as countries begin to experience growth, there is gradual improvement in environmental quality over time, countries eventually realize that in the end, the best and probably the only way to attain environmental quality is to become rich (Stern, 2004). According to Cole (2003), his strand of argument has been supported by various researchers and environmental economist like Lomborg (2001), who relied immensely on the 1992 World Development Report. Although the application of EKC on pollutants and other environmental impacts is not exhaustive, the hypothesis has however been considered as a stylized fact by most environmental economists (see; Lin *et al.,* 2016 & Twerefou *et al.,* 2019) and that it requires theory in its explanation.

In the past, most environmental movements and environmental scientists have claimed the threatening nature of the EKC hypothesis on growing economies (Meadows *et al*., 1972). Stern (2004) however refutes this debate, positing that, given that the EKC hypothesis is correct, it should not seem more threatening to a nation but instead focus on economic growth as that would be the most probable means to eventually restoration or improvement in environmental quality. A graphical presentation of the EKC is depicted in figure 3.1 below.

It is salient to note that the theoretical EKC graph does not explicitly express time as a dimension and hence the use of the EKC to justify policy issues- which has to do with time- would not be enough. It is strictly by comparing two countries would the inverted U-shape as indicated by Figure3.1 be derived. The EKC can only be used to influence policy if the time dimension is incorporated. Each country has a unique EKC and so by including changes in income which inherently signifies time would this hypothesis be useful for policy.

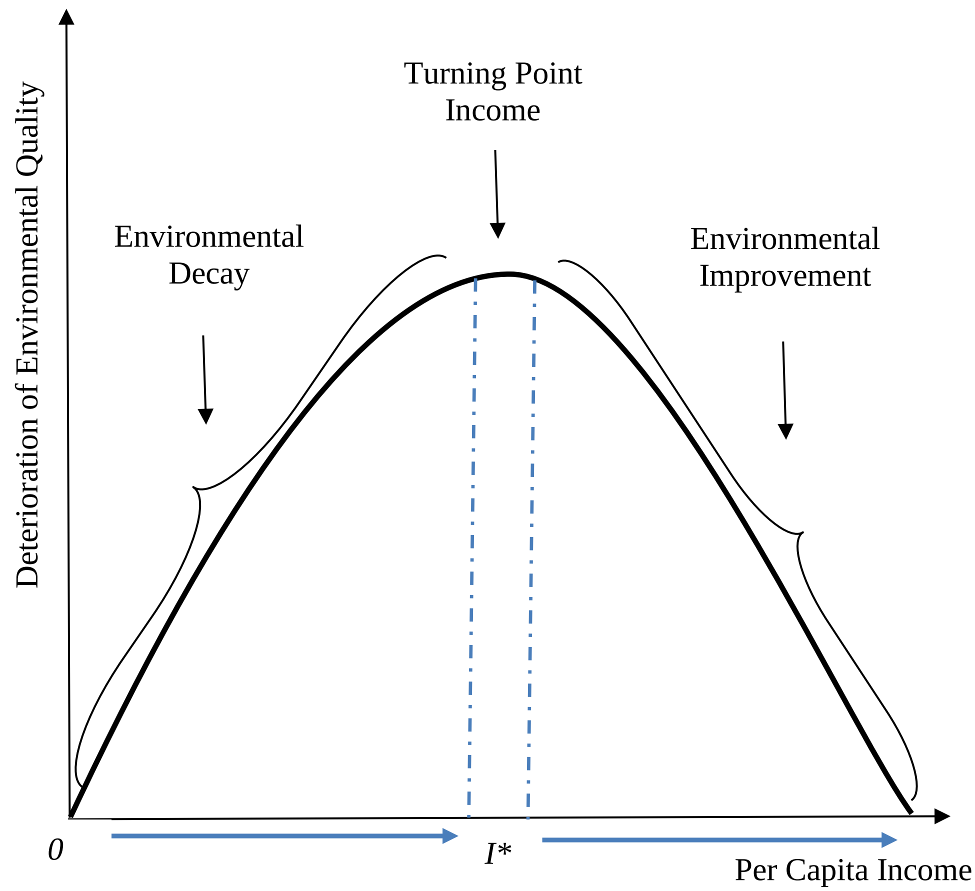

Figure 3.1: The Environmental Kuznets Curve (EKC)
Source: Stern, 2004

The EKC hypothesis also presents a notion that the curve must not be considered as utterly smooth as depicted by figure 3.2 below. Figure 3.2 sometime gives a wrong impression. Figure 3.2 represents a general idea of the hypothesis and therefore, does not necessarily depict what things are actually like in real life. As indicated by Figure 3.2 the relationship between environmental quality and *per capita* income is an Inverted U-shape which is jagged rather than smooth.

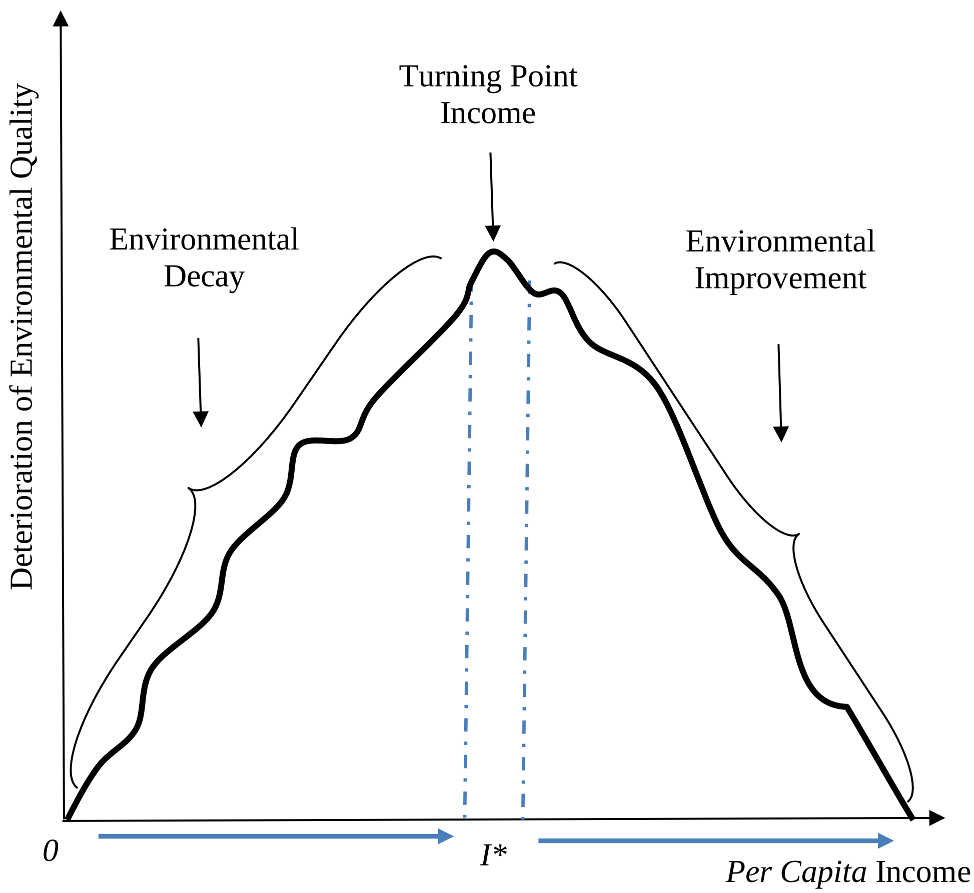

Figure 3.2: Realistic Nature of the Environmental Kuznets Curve (EKC)
Source: Stern, 2004

3.1.2 Pollution Haven Hypothesis (PHH)

The PHH is the assertion that industries would locate themselves in regions with less stringent environmental policies and regulation. Thus, it posits that regions with weak environmental regulation – pollution havens- would attract or serve as a place conducive for industries relocating from tight environmentally regulated regions (Temurshoev, 2006; Di *et al*., 2004; Dietzenbacher *et al*., 2004 & Levinson *et al*., 2002).

The hypothesis instinctively implies tight regulations raises the cost of vital inputs of goods with pollution intensive productions and in turn, reduce regions with a comparative advantage in those goods. According to the pollution haven hypothesis, developing countries lose from trade, that is, they experience deterioration in environmental quality when they open up to trade mainly due to the failure of their government to develop and implement strict and proper environmental policies and regulations (Busse, 2004).

However, evidence of this hypothesis is empirically elusive (Grether *et al*., 2006; Cole & Elliot, 2003b). A substantial amount of studies that have investigated the pollution haven hypothesis found little evidence to back this claim. Cole & Taylor (2004) found little convincing evidence to support this hypothesis in their paper, which examined the links between income *per capita* & environmental quality. This can be attributed to the idea that industries are faced with two concerns- the pollution haven and abundance and availability of factors of production - and the cancelling out of these two decision-influencing components (Korves *et al*., 2011; Cole & Elliot, 2005) lessens the argument of this hypothesis. Hence firms may not necessarily relocate because of weak environmental regulations.

3.1.3 Factor Endowment Hypotheses

This is developed on the premise that countries would produce and export goods and services they have in abundant endowment. It opines that it is not the variations in pollution regulations but rather the variations in factor/ resource or technological endowment that determines trade. Notably, it asserts that capital abundant countries would export capital-intensive, otherwise known as dirty goods, which enhances its production and hence increasing pollution in capital-abundant countries (mostly developed countries). On the contrary, pollution decreases in countries with capital non-abundance as a result of the reduction of the production of pollution-intensive goods, since there is no comparative advantage of producing commodities in developing countries. In all, the trade-induced environment effect both domestically and globally depends on the relative comparative advantages facing countries.

The factor endowment hypothesis is significantly different from the Ricardian theory that postulates countries face different costs to produce a similar commodity and therefore if each country produces and exports the commodities that each has comparatively lower costs, then all parties involved in trade benefit. This theory, considering two countries producing two commodities, assumes that each country shares similar technology and costs in the production of two commodities and have similar consumption preferences. However, it assumes that producing each commodity require different factor intensities. For example, a textile industry would require more labour to capital than the automobile industry, which would require more capital per unit of labour. Consequently, this theory predicts that in the presence of trade liberalization, capital abundant countries specializing in capital-intensive production would hence produce pollution-intensive commodities while on the other hand, labour-abundant countries specializing on labour intensive production would produce relatively environmentally cleaner commodities.

3.1.4 Porter Hypothesis

The Porter Hypothesis (PH) was first developed by Harvard professor Michael Porter who defies conventional wisdom by arguing that a well-designed environmental regulation can, in fact, enhance competitiveness (Ambec *et al*., 20011), that is it would not only benefit the environment but also (sometimes) polluting firms hence improving general productivity. The PH claims that "strict environmental regulations" do not necessarily impede "competitive advantage" against rivals; but rather, they often enhance it (Porter, 1991; Ambec *et al*., 2011). It postulates that the cost of compliance to environmental regulations such as environmental tariffs, taxes, tradable emission permits, etc. may be offset by the adoption of innovations they generate.

Porter and his coauthor van der Linde (1995) states in their paper emphatically that; appropriately crafted environmental standards which are regulations imposed on firms are not detrimental but are beneficial to them. This, in essence, says that controlling pollution is associated with enhancing the productivity with which resources are used in the production process. They argue that a properly designed environmental standard can result in innovation which may partly or wholly offset the cost of complying with them. This cost cancellation, which they termed "off-setting cost" cannot only lower the cost of meeting environmental standards but can also result in absolute advantages over firms in other jurisdictions not faced with similar standards. Porter and van der Linde (1995) posit that appropriately designed environmental standards can breed innovations that can at least offset the cost associated with compliance. According to them, there is a possible absolute advantage generated by local firms over their foreign comparators who do not have stricter or well-fashioned environmental regulations. Thus, a properly crafted system of environmental regulation can enhance firm competitiveness by stimulating innovation.

Figure 3.3 below summarizes the main ideas of the PH and its associated causal links as described by Porter and van der Linde; if environmental standards are properly designed and imposed earlier; they are beneficial to the firm facing it and the environment as a whole.

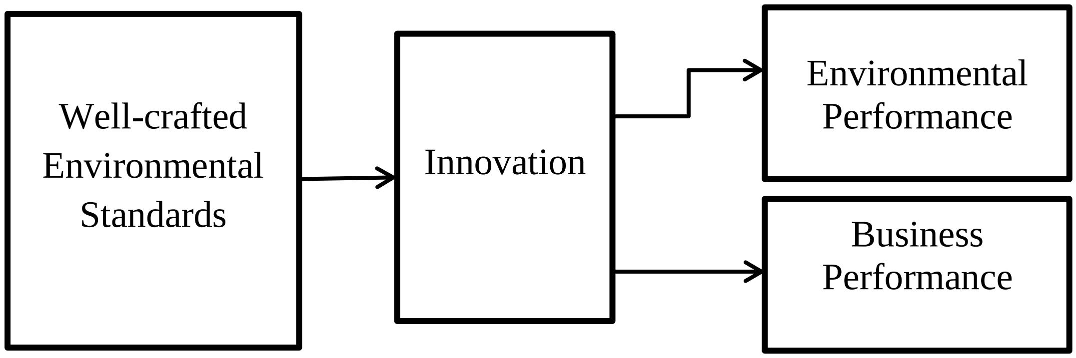

Figure 3.3: Graphic Representation of the Porter Hypothesis
Source: Adopted from Ambec et al., 2011.

Porter and van der Linde indicate that foremost regulation hints firms about the possibility of resource inefficiencies and possible technological enhancements as well as also help firm focus on information gathering that in the long run can affect it (firm) positively. They go on to hint that regulation reduces the doubt associated with environmental investments, creates pressure that motivates progress and finally standardizes the transitional playing ground.

One cannot deny the impact of the PH; it has triggered an exciting debate both theoretically and empirically. Theoretically, the PH completely defies the orthodox view that environmental regulations are detrimental to the firm's subject to the regulation. In the empirical sphere, the challenge is to decide whether the reported evidence supports that environmental standards tend to erode firm's competitiveness, as conventional point of view defends it or, on the contrary, it is likely to foster competitiveness. Porter and van der Linde (1995), however noted that, innovation simulations resulting from properly designed environmental regulation cannot absolutely offset its associated costs of compliances, particularly in the short run, which is relatively inadequate a time for innovation-based solution to be realized through learning.

This hypothesis, however, has met several criticisms stirring from the conventional models which forecast dumping and pollution as a result of trade rather than increased competitiveness from environmental standards. It is also criticized for ignoring the basic profit-maximization behaviour of firms which is more likely to push firms towards innovation rather than environmental regulation. Critics, in addition, argue that in the situation where regulations are not stricter, the firm that adopts more friendly environmental standards is likely to be at a competitive disadvantage with trade openness (Hanley *et al*., 2001).

3.2 Theoretical underpinnings of International trade

The trade theory that first emphasized specialization and division of labour in production was rooted in the idea of the theory of comparative advantage which was first developed by the Father of economics- Adam Smith in his book *The Wealth of Nations* which was published in 1776. However, the law of comparative advantage as developed by David Ricardo, forms a compelling argument for international and free trade between nations. It amplifies why it is mutually beneficial for nations to trade. It postulates that when nations specialize in what they have comparative advantage in, they become more efficient in producing the good or service and thus trade for their other needs which in turn becomes beneficial to them and the world as a whole.

In economic theory, the law of comparative advantage refers to the opportunity cost associated with the production of a good or service a nation or individual incurs compared to the other nation or individual (Aldrich, 2004). A country has a comparative advantage in the production of a good or service if it is relatively more efficient in the production of that good or service. Efficiency here is measured in terms of relative magnitudes. Comparative advantage elucidates how trade can generate value for two economies even when one can produce all goods and services with fewer resources than the other. This referred to as the gains from trade- net benefits from an outcome of trade. Trade theorists have further modified this theory into factor endowments which are the Hecksher-Ohlin Theory (1933) and Stolper-Samuelson (1941).

3.2.1 Hecksher-Ohlin (H-O) Theory of Trade

This theory borrows from the theory of comparative advantage and postulates that countries export not only what they most efficiently produce but also what they abundantly produce. It proposes that given free trade low-income countries would concentrate in the production of goods and services that are intensive in the resources that they are endowed with in relative abundance. The theory argues that trade is necessary because of variations in labour and productivity of different countries and therefore developed countries export generally capital-intensive products whiles developing countries export mainly labour-intensive products. Furthermore, the H-O theory elucidates why resource-abundant (for example, labour-abundant) Less Developed Countries (LDCs) are likely to produce and export labour-intensive goods and services and in return for imports of capital-intensive goods because of their price advantage and relative cost facilitated by international specialization. Trade, as specified to the H-O theory thus serves as an opportunity for a country to take advantage of its plentiful resources through a more concentrated and rigorous production.

3.2.2 Stolper-Samuelson Theory of Trade

The Stolper-Samuelson theory of trade is an extension of the H-O model. It stipulates that as the price of a commodity increases, there is income generation to the intensively utilized input of production. This theorem explains the circumstances under which free trade in services and goods constricts dissimilarities in commodity prices between countries, and hence the incomes of the inputs of production are also brought in line. That is, free trade offers a replacement for the free movement of inputs of production across borders. According to this model, free movement of factors of production can lead to nationwide resource allocation to arears of relative scarcity from areas of relative abundance, and thereby standardize factor prices across all countries to promote efficiency in the use of the resource.

3.3 Theoretical underpinnings of trade liberalization

"Increased trade liberalization, increased trade, increased production, increased energy use and climate change", while considered as detached issues until the nineties, has received the attention of scholars researching the environment and trade (Stoessel, 2001). It has been argued that trade is essential for every country. Policymakers argue that there is first of all gains from trade. They also argue that when countries buy and sell from each other, the exchange is always mutually beneficial, and can redistribute incomes where the gains from distribution outweigh the loses (WTO, 2012).

Furthermore, economic theory stipulates that trade permits countries to specialize in the production of commodities they can produce relatively more efficiently. Besides, trade liberalization allows for the exploitation of economies of scale. Trade enhances the ability of firms to produce on a bigger scale. When trade is liberalized, firms are faced with a more substantial demand and therefore they would be able to pick products at a more efficient level of production thus saving costs. These lead to lower costs of production, which would benefit the country as a whole.

3.3.1 General effects of Trade on the environment

The theory stipulates a close and dynamic trade-environment relationship. Antweiler *et al*. (2001) argue that rather than considering the relationship between the environment and trade openness, it is crucial to consider the interaction between what he calls the scale, technique and composition effects resulting from country-specific characteristics and trading opportunities. All these three decomposed effects act together when trade is liberalized.

The scale effect of trade defines the effect on pollution from a rise in production value weighted by the autarky price ratio. Thus, it is the pollution associated with trade-induced increase in economic activities. With international trade, there is increased utilization of economic resources, hence, increased production all other things being equal. The increases in production, especially in manufacturing would be associated with increased energy utilization from fossil fuels, leading to increased emissions. The implication of the scale effect is that, the increases in income induced by trade subsequently results in pollution of the environment. For instance, there was an assertion on the increased use of cross-border transportation services in the 2009 annual report of WTO, and this was argued to result in increases in greenhouse emission. Empirical justification of this nexus seems blurred.

The technique effect defines the reducing effect on pollution resulting from the use of advanced and environmentally friendly methods of production. According to Korves *et al.*, (2011), international trade accounts for a little over 75 percent of technological transfers. This has been argued to be significantly influenced by research and development (R&D) which results in reduction in pollution per capita via the use of pollution-reducing technologies. Empirical studies such as Stoessel (2001), Cole and Elliot (2003) and Copeland and Taylor (2004) among others argued that technique effect of trade results in improvement in environmental quality.

The composition effect does not have a strict definition. It derives from the comparative/relative advantages that a country has in the generation of pollution-intensive goods and differences in environmental policies, i.e. PHH versus FEH. Comparative advantages that results from factor endowment (capital-labour ratio), suggests that countries with high income will produce more damaging effects on the environment due to their comparative advantage in the production of pollution-intensive goods relative to the developing or relatively low-income counterparts which is characterized by low capital-labour ratio (Korves *et al*., 2011). Notwithstanding this advantage, advanced economies equally suffer from comparative disadvantage in production of pollution-intensive goods. This is due to the strict regulatory framework which makes the cost of polluting high. The relatively expensive abatement cost surges the cost of producing dirty goods. Developing countries on the other had have relative advantage in pollution-prone industries, making them haven for pollution (Korves *et al*., 2011). Following from this argument, countries with laxer environmental regulation, especially developing countries, are expected to lose from trade through influx of economic activities that damages their environment. This contrasts the situation for developed countries who are likely to become clean (or gain from trade).

The empirical works on trade openness and environmental quality are relatively extant. Although the area of trade impact on environmental quality has received ample attention in recent time, majority of the works are tailored towards developed economies with little or close to no work on developing economies (excluding China). China remains one of the fastest growing developing countries in the world (World Bank, 2019) accounting for why research interest in China has received relatively more attention (Chang, 2012; Gozgor & Can, 2017). This principally due to their rapid growth (expected to stabilize at 6.2% in 2020) and their apparent volume of trade with the rest of the world.

The importance placed on the global environment has aroused various studies on the effect of pollution-related activities on the environment, particularly, cross border activities like trade, foreign direct investment, and foreign aid among others.

3.4 Empirical Review

Review of literature has shown a plethora of empirical evidence on the trade-environment nexus, (Antweiler, Copeland & Taylor, 2001; Frankel & Rose, 2005; Bernard & Mandal, 2016; Jafari, Farhadi & Zimmermann, 2017) however, it continues to attract increasing attention especially in emerging and developing economies. The section reviews empirical evidence on trade-environment nexus. This section is organized according to themes; explicitly focusing on studies which found positive evidence for the trade-environment nexus, studies which found contrary evidence and studies whose results were inconclusive and their corresponding methodologies therein.

Earlier studies such as Grossman and Krueger (1991) which examined the impact of North American Free Trade Agreement (NAFTA) on SO_2 concentration instigated more detailed studies on the environmental impact of trade openness. Majority of the studies in the nineties (Tobey, 1990; Grossman & Krueger, 1991; Safik, 1994; Selden & Song, 1994; Panayiotou, 1997) focused on the basic EKC model or extended version of EKC and executed a regression of trade openness and various control variables on some measures of environmental quality. Although EKC application in examining trade-environment relationship is simple in nature and easy to execute, Stern (2004) critique it based on of econometric misrepresentation. Aslanidis (2009) also contends on the restrictive nature of the EKC model and its statistical weakness. Grossman and Krueger (1991) based on their basic EKC model that trade liberalization was good for the growth of Mexico and may even lead to a reduction in pollution.

Subsequent studies endeavored to examine the environmental impact of trade by adopting as the basis of empirical specification, the theoretical model developed by Antweiler, Copeland, & Taylor (2001). The specification based on Antweiler *et al*., (2001) was argued to be methodologically powerful and useful in decomposing the environmental effects into its respective technical, scale, and composition effects, with their respective magnitudes. For instance, Antweiler *et al*., (2001) employed a panel data for 109 cities for 25 years (1971-1996). By employing the general equilibrium analysis on relative pollution concentration, real *per capita* income, trade openness and GDP per square kilometer, the study interacts trade with income and capital-labour ratio at various levels to cater for environmental policies, factor endowment, as well as scale and technical effects and made interesting findings. They found negative technical and composition effects and a positive scale effect on SO_2 concentration and concluded that the environmental impact from trade is positive.

Taking cognizance of greenhouse gases (SO_2) as the main environmental and climate change concerns, Cole (2003) adopted the Antweiler *et al.*, (2001) theoretical framework (ACT model) on a panel data of 32 countries for the period 1970 to 1995 for developing and developed countries. Employing CO_2, NO_x, SO_2, and Biochemical Oxygen Demand (BOD) as a measure of environmental quality found evidence in support of the inverted U-shape EKC. The study also concluded that intense trade activities result in lower domestic emissions for sulfur oxide.

In terms of directional effects, existing literature on the trade-environment relationship shows evidence of negative, positive and ambiguous effects. Many studies including Grossman and Krueger (1993) found trade to be beneficial while others reported trade to have detrimental effect on the environment of economies, especially developing economies (Chang, 2012; Shahbaz, Hye, Tiwari & Leitao, 2013). Grossman and Krueger (1993) one of the pioneering works in this area study the impact of NAFTA on Mexico. They found the relative factor endowment to determine the pattern of trade for the US and Mexico and concluded on the positive impact of trade on the environmental quality of Mexico.

Following the pioneering work of Grossman and Krueger (1993), Copeland and Taylor (2004) were one of the significant studies that report increasing trade to positively impact on environmental quality through improvement in competitiveness with subsequent advances in technology to developing economies.

The works of Antweiler *et al*., (2001) and Cole (2003), however, were criticized on econometric grounds despite their examination of environmental impact of trade in greater detail. Frankel and Rose (2005) and Managi, Hibiki, and Tsurumi (2009) argued on the simultaneity bias between trade, income and emissions, which was ignored in previous studies. Other authors such as Stern (2004), Managi *et al*. (2009) and Wagner and Grabarczyk (2016) also contended on the issue of multicollinearity, endogeneity, omitted variable bias, heteroscedasticity, and the possible cointegration between income, trade, and emissions.

In contrast, Chang (2012) and Shahbaz *et al*. (2013) found a trade to be deleterious to the environment by increasing emission and depleting natural resources. Chang (2012) uses Vector Autoregression (VAR) to analyzing the nexus existing between trade openness and the quality of the environment in China and indicated inconclusive results. The study spanned a period of 28 years. They looked at the effect trade openness has on environmental quality. Their results indicated that exports have a positive effect on SO2 emissions while imports and FDI had a positive effect on solid waste generation and trade openness had significantly no effect on wastewater and thus were unable to concretely conclude whether openness is good or bad for the environment in China.

Contrary to studies that found a significant effect of trade and environment, Sharma (2011) in an examination of the relationship for 69 countries and employing a dynamic panel data model found no significant impact of trade on the environment in the global panel. However, GDP was found to increase CO_2 emissions while urbanization reduces it.

Managi *et al*., (2009) also adopted three systems of equations: 1. Endogeneity growth model for income, 2. the specification based on the gravity model for trade, and 3. environmental quality equation. Similarly, Managi *et al*., (2009) employed the Instrumental Variable (IV) technique to determine whether trade is beneficial to the environment. The study uses panel data on 88 OECD and non-OECD countries and reports inconclusive results. They assert that the role of trade on the environment is dependent on the type of data, pollutant, time-period and the country/region in question. They argue that the overall/total effect of trade on the environment cannot be inferred from the sum of the three decompositions, Antweiler *et al*., (2001) purported. The study also went on to separate the role of trade on the environment into short and long-run effects. They employed the dynamic General Method of Moments (GMM) to separate these time-specific effects and found that the long run trade effects on the environment is negative for all pollutants (CO_2, SO_2 and BOD) in OECD countries but positive for non-OECD countries. The results however, for BOD was negative for all the countries considered.

McCartney and Adamowicz (2005) evaluates the impacts of trade liberalization on carbon dioxide (CO_2) emissions and organic water pollutant with panel data by making use of both quadratic and cubic specifications for the effect of trade on the environment. They address the problem of heterogeneity by controlling for country-specific characteristics that could distort the competing scale, technique and composition effects. They reported that trade meaningfully increases emissions and hence reduces environmental quality.

Frank and Rose (2002) and Kukla-Gryz (2009) also asserted that at lower income levels, trade is detrimental to the environment, but trade becomes beneficial at higher income levels which gives credence to the environmental Kuznets curve. In their analysis, they sought to solve the problem of endogeneity between income and trade by using the exogenous determinants of trade as proxies to separate the how trade openness affects the environment. Their study concludes, using Sulphur dioxide (SO_2), and particulate matter as proxies for environmental quality, that trade openness has a significant positive impact on emissions. That is, trade is bad for the environment.

This paper using the same 88 countries as Managi *et al*. (2009) but for extended years (1963-2000), Tsurumi and Managi (2010) examined the impact of trade openness on CO_2 and SO_2 emissions found mixed results. They employed the semiparametric method of panel analysis using quadratic specifications and found the technique effect to produce reducing effect of trade on SO_2 while that on CO_2 showed otherwise.

Similarly, Cole and Elliot (2003) adopted a specification based on the ACT and made use of cross-sectional data for 26 developing and developed countries for a 16 years period (1975-1990) to examine the trade effects on CO_2, SO_2, NO_x, and BOD as a measure of environmental quality from trade openness. They sought to determine whether the compositional variations in pollution resulting from trade openness in different regions is accounted for by differences in capital, labour endowment and environmental regulations. Their study uses data on CO_2, SO_2 and NO_x as a proxy for pollution and biochemical oxygen demand (BOD) as a measure for water pollution. They find inconclusive results for the various pollutants. They argue that trade-environmental relationship tends to vary when it is measured in emissions to when it is measured in concentration. Specifically, energy use, SO_2 and NO_x emissions were found to increase with trade due to the superimposition of the scale-technical effect over the composition effect. The implication is that trade enhances production and output growth, which produces more emissions, yet the technological approach to abatement no longer supports the increasing output growth. The results, however, showed reducing the effect of trade on BOD emissions. In conclusion, they remarked that the environment benefits from trade for OECD countries but detrimental to the environment of non-OECD countries.

In an attempt to address the two-way relationship between trade and income, Frankel and Rose (2005), Managi *et al*. (2009) and Tsurumi and Managi (2010) modelled the endogeneity of trade separately. Frankel and Rose (2005), for instance, accounted for trade endogeneity by making use of exogenous geographical factors of trade as instrumental variables. They found reducing the effect in air pollutions for trade. Specifically, they found significance statistically but with lacking effect for concentrations of particulate matter, moderate and high effects for SO_2

concentrations respectively. They concluded that there is little evidence that the suggests damaging effect of trade on the environment.

Besides, Jafari, Farhadi, and Zimmermann (2017) in a recent study, found no significant impact of trade on the environment. Jafari *et al*., (2017) employed a similar technique of dynamic model as Frankel and Rose (2005), and Managi *et al*., (2009) but with Arellano-Bond (1991) GMM estimation, and adopted the traditional EKC procedure. The data included a panel of 166 countries for 20 years period (1980-2009) and using CO2 as the only measure of environmental quality they, however, made interesting findings on the role of government on environmental quality, reporting a negative significant negative impact.

Other strands of literature analyze the trade-induced environmental effects from the perspective of the role of government and other socio-economic factors (Halkos, 2012; Barro, 1991; Afonso & Furceri, 2008, Bernauer & Koubi, 2006). Jafari *et al*., (2017) estimate a dynamic panel using GMM and finds that increasing government spending on economic growth results in significant negative effects of trade on the environment. Studies such as Fredriksson, List, and Millimet, (2003), Bernauer and Koubi, (2004); and Morrison, 2009 found democratic arrangements and political freedom to influence the effect of trade on the environment. Ibrahim *et al.*, (2016), Tamazian and Rao (2010) argued for institutional efficiency or quality. Chakraborty and Mukherjee (2013) also employed the Corruption Perception Index (CPI), Hybrid HDI, and Democracy Index score in examining the impact of trade on the environment.

3.5 Conclusion

Review of literature in the current study have shown the analysis of trade's impact on the environment from different methodological perspectives, and on the basis of data type, measurement related issues, as well as the country(ies) and periods of analysis. Systematically, the methodological developments in the trade-environment analysis have been reviewed from the simplest version of EKC theorized models, ACT and extended ACT model, which accounted for methodological issues in earlier studies. Also, studies that adopted different measures of environmental quality have been reviewed with crucial emphasis on pollutant emissions and pollutant concentrations.

Review of literature shows evidence of a plethora of studies on the trade-environmental quality nexus, albeit ambiguity in impact and causal relationship. According to Bernard and Mandal. (2016) the literature on the relationship between trade and environment can be grouped into the causality and impact analysis. This current study examines both the effect of trade on environmental quality and the causal relationship between the two key variables and further examines how the differences in environmental qualities between Asia and Sub-Saharan Africa (SSA) is accounted for by trade openness. Implicitly, the mixed findings in the literature suggests that the influence of trade openness on the environment is largely dictated by researcher's choice of method, countries, years of consideration, as well as the definition of environmental quality and the number and type of other variables introduced or employed.

Further and most importantly, the plethora of existing literature on the trade-environment relationship has mainly focused on the impact and effects of trade on the environment, ignoring the possible causation from the environment to trade. Implied in this is the existing gap in the literature on the causal relationship between trade and environment. Many studies such as Omri *et al*., (2015) which examined the causal relationship in this regard focused on emission and economic growth. It is therefore imperative to bridge this gap by not only examining trade-environment nexus but also investigate the direction of the causal relationship between these variables.

We therefore, in this study move build on the basic EKC, adopt a more robust and efficient estimator to study this nexus. We set apart by also not only concentrating on correlation relationship but the causal relationship which was ignored by almost all the studies reviewed. Our data is current and we concentrate on the regions that have received the least of attention over the years.

CHAPTER FOUR

METHODOLOGY

4.0 Introduction

This chapter focuses on the methodology employed in this study. The chapter is divided further into five (5) main sections. The first section presents the theoretical framework that informed this study, the second section focuses on the empirical model and modifications made to the model of estimation. Section three covers the data used, its source and its definitions. The fourth section presents the econometric procedure and diagnostics and finally section five covers the strategy of estimation of our empirical model.

4.1 Theoretical Framework

Trade is without question an essential aspect of every economy. Trade leads to employment, increased income levels and access to plentiful economic commodities. Theory and empirical literature stipulate that trade contributes to economic growth through globalization. In the same light, increased trade has implications for the environment. Managi *et al*., (2009) stipulate that more trade openness increases the scale of production, *per capita* income and hence affects the environment. Growth in global trade and foreign direct investment also goes hand in hand with an increase in manufacturing and production. An increase in production (especially increased industrial production) leads to an increase in pollution and thus a reduction in environmental quality. This, in sum, gives a clear picture of the dynamic relationship between trade and the environment.

The theoretical framework for this study is developed from the various theories that explain the relationship between trade, real income *per capita*, and environmental quality which is defined by the levels or rate of pollution (emissions). First, the theoretical arguments on the positive effect of trade openness on real income *per capita* have been clearly espoused, and deeply rooted in the theory of comparative advantage by Smith-Ricardo, to the model of trade under imperfect competition of the Helpman-Krugman model. This is fairly backed by empirical literature (Frankel and Rose, 2002). Given the direct relationship between trade and economic growth (real income *per capita*), the trade-environment nexus would follow the Kuznets hypothesis of an inverted-U shaped relationship where pollution increases with trade openness (real income *per capita*) via the scale effect, and decreases via the composition and technique channel (Frankel and Rose, 2002).

Following from theory, the effect of trade openness on environmental quality is entirely ambiguous. Antweiler *et al*., (2001) argued in their paper that the impact of liberalizing trade on the environment is determined by the relative elasticities of the scale, technique and composition effects and therefore not conclusive; the effect could be positive or negative. Furthermore, the race-to-the-bottom hypothesis which postulates an adverse effect has been the most widely discussed. These proponents hypothesize that countries, especially those with unfavourable trade experiences, adopt loose or less stringent environmental policies in their bid to withstand international competitiveness.

On the other hand, however, the gains-from-trade hypothesis postulates a possible positive environmental effect from trade openness. Notwithstanding the plausible intuition, this phenomenon has received less attention, hence, less widely recognized according to Frankel and Rose (2002). Trade promotes consumer sovereignty and the availability of a wide range of market output and environmental goods promises consumer welfare. As consumer welfare increases, they are more likely to increase their demand for quality, thereby promoting international demand for a quality environment. This ratchets up international environmental standards, mainly more operational for production standards and not necessarily for standards relating to production methods and processes (Porters, 1995; Vogel, 1995; Braitwaite and Drahos, 2000) and breeds managerial and technological innovation (Schmidheiny, 1992; Esty & Gentry, 1997; Eskeland & Harrison, 2002). The increasing demand for high environmental standards will promote effective regulation and ultimately translate into the desired reduction in pollution, thereby promoting a sustainable environmental quality (Grossman & Krueger, 1995).

This is evident in Esty and Gentry (1997) on the infusion of environmentally friendly production techniques that originates from countries of high environmental standards to host countries for various reasons;

> *"First, many companies find that the efficiency of having a single set of management practices, pollution control technologies, and training programmes geared to a common set of standards outweighs any cost advantage that might be obtained by scaling back on environmental investments at overseas facilities. ...Third, the prospect of liability for failing to meet standards often motivates better environmental performance..." (Esty & Gentry, 1997: 161).*

Deducing from the above discussions, we go on to develop a model for the trade-induced effect on the environment. We develop this model based on the work of Antweiler *et al*., (2001). In this model, we assume;

i. a small open economy

ii. they produce only two goods (A&B) with inputs; capital(K) and labour(L)

iii. industry Z is a capital-intensive and the production of good A generates pollution as a by-product while the production of good B is labour-intensive and does not pollute.

iv. the economy faces trade restriction λ.

v. there exist constant returns to scale and hence the production technology for *A* and *B* is specified in unit cost function as;

$$C^A (w, r) \text{ and } C^B (w, r)$$

Where w = wage or reward for labour

r = rent or reward for capital

The function that draws the link between environmental quality and economic activity is specified as below;

$$E = tA = tCS \tag{1}$$

Where *E* is environmental quality

t is the pollution intensity of industry Z

C is the relative importance of the dirty industry in the economy.

Where C is the share of *A* (pollution intensive good) in total output. The above equation provides a simple decomposition: environmental quality (*E*) depends on the pollution intensity of the dirty industry *t*, the relative importance of the dirty industry in the economy *C*, and the overall scale of the economy *S*. In differential form, equation (1) is rewritten below.

$$\hat{E} = \hat{S} + \hat{C} + \hat{t} \tag{2}$$

From equation (2) ^ denotes the percentage change in the variables with a unit change in trade openness. $\hat{S}$ depicts the scale effect which captures the change in environmental quality as a result of an increased level of production and thus the final product of production, holding constant the production mix.

$\widehat{C}$ measures the composition effect, which captures the effect of a unit change in output-mix of the economy on the environment. $\hat{t}$ measures the technique effect. Hence holding the scale of the constant, the economy would generate more pollution if it dedicates more of its resource to produce A. Therefore, an increase in the emission or pollution world lessens the environmental quality.

We further decompose equation (2) to show how the individual components indicated above influence overall pollution. We set good *B* as a commodity of value; we denote the relative price of *B* as *p*. However, because countries vary in terms of geographical and production factors such as land size, location, closeness to production supplies, population and also trade barriers, domestic prices will differ from global market prices. Therefore, we specify the relative price of commodity *B* in the domestic market as;

$$p^d = \lambda p^w \tag{3}$$

Where the domestic price (p^d) is a proportion (λ) of the world price (p^w) of the world of good *B*. λ is also a measure of the intensity of trade restrictions in the domestic economy. We further assume that the domestic economy is a net exporter of commodity *B*. We therefore estimate the overall effect of a change in trade restrictions (λ) on the environment. We account for the change created in the techniques of production *t*, the scale of output *S* and the composition effect *C* by the unit change in λ. Thus, we differentiate equation (1) with respect to λ holding p^w and factor endowment constant. This is specified in equation (4) and (5) below;

$$\frac{\delta E}{\delta \lambda} * \frac{t\lambda}{E} = \frac{\delta S}{\delta \lambda} * \frac{\lambda}{S} + \frac{\delta C}{\delta \lambda} * \frac{\lambda}{C} + \frac{\delta t}{\delta \lambda} * \frac{\lambda}{t} \tag{4}$$

$$\frac{\delta E.\lambda}{\delta \lambda.E} = \alpha_1 \frac{\delta S.\lambda}{\delta \lambda.S} + \alpha_2 \frac{\delta C.\lambda}{\delta \lambda.C} - \alpha_3 \frac{\delta t.\lambda}{\delta \lambda.t} \tag{5}$$

The dependent variable in equation (5) above measures the total impact of the various factors on the environment to a unit change in trade restrictions. The first term to the right is the measure of trade restrictions elasticity of the scale effect on the environment. The second term measures the trade restriction elasticity on the composition effect and the last term measures the trade restriction of the technique effect on the environment. Hence the effect of a unit change of trade restriction on the environment is determined by the relative elasticities between the scale, technique and composition effect (Antweiler *et al*., 2001). The scale and technique effects are generally positive and negative, respectively, while the direction of the composition effect is usually ambiguous.

The argument espouse above forms the basis for the conceptual framework for this study as presented in figure 4.1 below. Presented in figure 4.1, there is a reverse causality between trade and real income *per capita* (GDP); hence trade openness can affect the environment through GDP: and can also be determined by the existing environmental regulations. The level of GDP is argued in this framework to profoundly influence environmental regulations, which is determined by the institutional arrangements of a country while the reverse relationship from environmental regulation to GDP is shown to be weak. Similarly, there is two-way causal, yet weak relationship between trade and environmental regulation. Impliedly, trade openness can be beneficial or detrimental to environmental quality and is summarized as indicated in figure 4.1 as follows;

1. Direct through GDP
2. Direct or through GDP but moderated by environmental regulation which is shaped by institutional arrangement or polity.

The net effect of trade openness on environmental quality is theoretically grounded on relative strength of the gains-from-trade effect and the race-to-the-bottom effect. This theoretically rooted debate has been subjected to various empirical examinations that have produced mixed findings. The concept presented in figure 4.1 therefore serves as the theoretical basis for this empirical study.

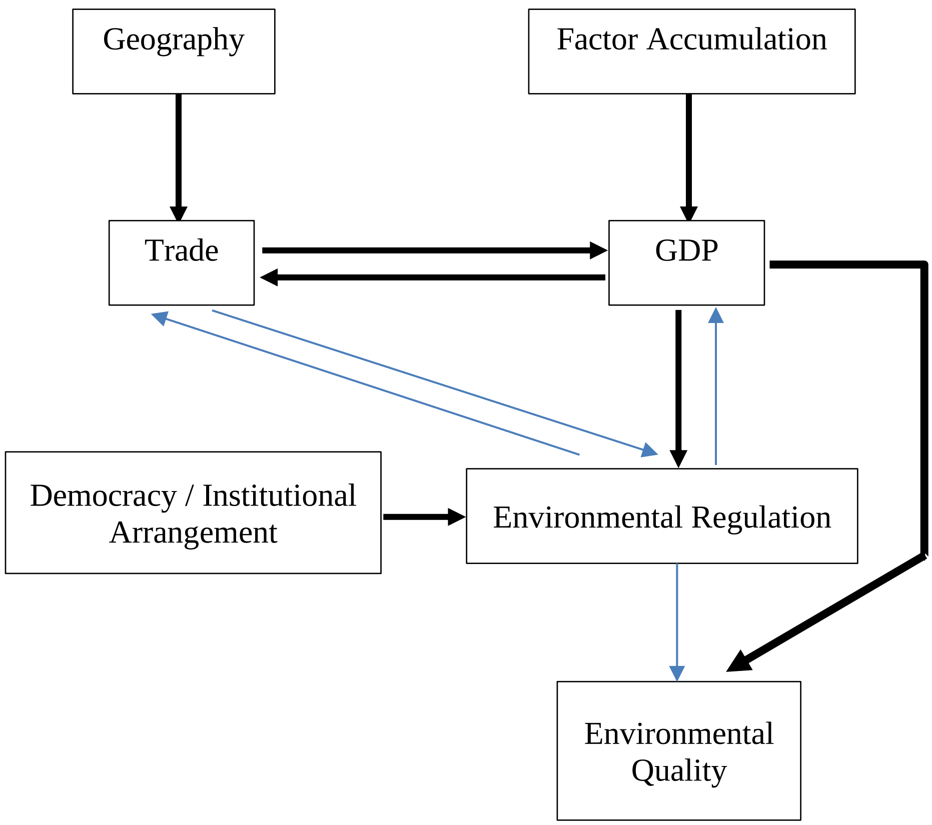

Figure 4.1: Theoretical framework on Relationship between trade and Environment
Source: Adopted from Frankel & Rose (2002)

4.2 Empirical Model Specification

As indicated earlier, different researchers have specified the trade environment nexus in several ways. Conventionally, analyzing the effect of trade on the environment relies on the Environmental Kuznets Curve model and it also control for other exogenous variables such as trade, population, FDI and land size. The EKC model is useful in measuring the overall impact of trade on the environment; however, it is flawed in the sense that it fails to separate the trade-induced scale and technique effects. The empirical specification aims to explain the impact of trade on environmental quality, hence, the need to adopt a model that permits the testing of the main hypothesis. The model adopted for this study allows for what Antweiler *et al*., (2001) term as factor endowment or comparative advantage to be captured. Thus, this study draws on and modifies the work of Managi *et al*., (2009) and specifies the environmental equation as follows:

$$lE_{it} = \alpha_1 + \beta_0 lE_{it-1} + \beta_1 RYPC_{it} + \beta_2 RYPC_{it}^2 + \beta_3 klr_{it} + \beta_4 klr_{it}^2 + \beta_5 (klr)_{it} RYPC_{it} + \beta_6 top_{it} + \beta_7 (rRYPc_{it})top_{it} + \beta_8 (rRYPC_{it}^2)top_{it} + \beta_9 (rklr_{it})top_{it} + \beta_{10} (rklr_{it}^2)top_{it} + \beta_{11} (rklr_{it})top_{it} + \beta_{12} FDI_{it} + \beta_{13} ER_{it} + \beta_{14} (ER_{it})(top_{it}) + \beta_{15} PGPLS_{it} + \beta_{16} RYPSK_{it} + \varepsilon_{it} \quad (6)$$

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

where lE_{it} denotes log of emissions (CO_2, NO_2, CH_4) of a country *i* over time *t*

lE_{it-1} =log of the lag of emissions

RYPC = real income *per capita*

klr = capital-labour ratio

rklr = relative capita labour ratio

top = trade openness

rRYPC = relative real GDP *per capita*

FDI = foreign direct investment

ER = environmental regulation and institutional arrangement

PGPLS = population growth per land size

$\beta_{i\,;}$ i= 0…15 = coefficients estimate and

ε_{it} = error term; consisting of two orthogonal components individual country effect (μ_i) and an idiosyncratic shock (η_{it})

Equation (6) differs from previously estimated models specifically that of Managi *et al*., (2009) in three regards. First of all, FDI is controlled for in the sense that with a region such as SSA who relies strongly on foreign technology and expertise; it would be interesting to see how it may or may not impact the environment. Secondly, Nitrous oxide is included as one of the environmental quality indicators because agriculture plays a significant role in the economies under study, and it is essential to include it since it emanates mainly from agricultural activities. N_2O is also considered in this study because, it has strong local effects, in addition, it is a by-product of production and its produced in varying quantities from country to country. Lastly, equation (6) is estimated with system General moments of methods for several reasons elaborated under the estimation strategy.

4.2.1 Decomposition of the empirical model.

Equation (6) comprised of the three different effects; the scale effect, technique effect and composition effect. The scale and technique effect are captured by the GDP *per capita* (Cole & Elliot, 2003). It is argued that institutional arrangement also influences the scale-technique effect and therefore, the interaction between GDP *per capita*, institutional arrangement and trade openness also helps capture the scale-technique effect (McCartney & Adamowicz, 2005). Hence the scale-technique effect (STE) in equation (6) is as below;

$$STE_{it} = \beta_1 RYPC_{it} + \beta_2 RYPC_{it}^2 + \beta_{14}(ER_{it})(top_{it}) + \beta_{16} RYPSK_{it} \quad (6a)$$

According to the EKC theory, β_1 and β_2 are expected to be positive and negative, respectively.

β_{14} could be positive or negative depending on the level of income of a country and their institutional arrangement. While according to Antweiler *et al.*, (2001), β_{16} is expected to be positive.

The composition effect is derived from equation (6) by removing from it the emissions variable (E_{it-1}), GDP *per capita* variables, FDI and that of institutional arrangement or environmental regulation. Thus, the composition effect ($COMP_{it}$), embedded in equation (6), including both the direct and indirect effects is specified as follows;

$$COMP_{it} = \beta_3 klr_{it} + \beta_4 klr_{it}^2 + \beta_5 (klr)_{it} RYPC_{it} + \beta_6 top_{it} + \beta_7 rRYPc_{it}\ top_{it} + \beta_8 (rRYPC_{it}^2) top_{it} + \beta_9 rklr_{it} top_{it} + \beta_{10} (rKLR_{it}^2) top_{it} + \beta_{11} (rKLR_{it}) top_{it} \quad (6b)$$

According to Managi, Hibiki and Tsurumi (2009), the additive function $\beta_3 klr_{it} + \beta_4 klr_{it}^2 + \beta_5 (klr)_{it} RYPC_{it}$ as part of the equation (6b) captures the indirect trade-induced composition effect.

Empirical studies such as Antweiler *et al*., (2003) predicts β_6 to be zero. The empirical literature has explored comparative advantage and the country's environmental policy and has concluded that countries that have strongly enforced environmental policies will have less comparative advantage due to competition losses. As a result, free trade is expected to harm developing economies who tend to have relatively laxer environmental regulations. The implication is that countries with low *per capita* income usually do not have a well-structured and enforced environmental policies, hence, suffer environmental damages from cross border trade with their high-income counterparts. Since low-income countries with weaker environmental regulation but have a comparative advantage in the pollution-intensive production would attract dirtier firms. The interaction between trade openness and real GDP per capita captures the pollution haven hypothesis, hence, β_7 is expected to be negative. The squared term of this interaction is included to account for the difference in relative capital-labour ratio and relative GDP (Cole, 2003) and therefore, β_8 is expected to be negative.

As a corollary, factor endowment theory postulates that economies with low capital-labour ratio has a relative disadvantage in pollution-intensive production and thus minimal pollution. Countries with high capital-labour ratio on the other hand tend to have a reltive advantage in the dirty industry and hence pollution might increase. This argument is catered for in the model using the interaction of relative capital-labour ratio and trade openness and its quadratic term. Borrowing from the hypothesis the a-priori sign for β_9 and β_{10} are negative and positive respectively. Lastly, β_{11} is indeterminate. It could assume a positive or negative sign.

4.3 Data and Variable Definition

The data is sourced primarily from the World Development Indicators (WDI). The data employed is up-to-date and current which covers 54 East Asian (7) and Sub-Saharan African (47) countries spanning from 1975-2018. These countries have hardly been studied concurrently studied in the trade-environment literature. This section goes on to present the meaning and brief description of the variables under consideration in the study.

4.3.1 Dependent Variables

Carbon dioxide (CO_2)

Carbon dioxide measured in kilotonnes is a global pollutant is emitted into the atmosphere through the burning of fossil fuels such as coal, solid waste, wood or trees as well as certain chemical reaction resulting from the production of certain mineral products such as iron sheets (IEA, 2017). Carbon dioxide is the most emitted greenhouse gas and it contributed to about 65% of the total GHG in the atmosphere (IPCC, 2014). CO_2 has received and continues to receive the most focus from environmental activists, environmental opponents, policy makers and scientist alike because, CO_2 has over the years caused the most climatic change (Somerville *et al.*, 2007).

Unlike other GHG such as methane and nitrogen oxide, CO_2 stays way longer in the atmosphere. After CO_2 has been emitted today, CO_2 is removed from the atmosphere after a century when it is emitted and could leave behind 20 per cent to last for about 800 years from the time of emission (Forster, *et al*., 2007). It is important to note that China in East Asia emits about 30 per cent of the global CO_2 and contributes to most of the industrial emission of carbon dioxide. SSA, on the other hand, may not necessarily feed into international trade considering that most countries in Africa are net-importers of industrial products coupled with the fact that most of Africa's export is raw in nature.

Nitrous Oxide (N_2O)

A significant modification of the model by Managi *et al*., (2009) is the inclusion of nitrous oxide as a proxy measure of environmental quality. Nitrous oxide is a local pollutant which is emitted mostly through agricultural activities such as the manufacture of fertilizer. Agriculture is a major source of income to majority of the SSA countries and employs over 60% of its pollution and therefore it is imperative to analyze if this greenhouse gas impacts the environment in any way. A little empirical work exists where N_2O is used to study the trade environment nexus (Cole & Elliot, 2003; Doudu; 2018) although they have in recent times increased at an alarming rate (IEA, 2017) and also immensely contributed to climate change and global warming. Nitrous oxide contributes about 6% to global warming (IPCC, 2001). Among the regions ranked in 2010 to be producing three-quarters of global nitrous oxide, Africa finds its name on that chart with 19%, Asia (36%) including China (18%) and the Latin America (14%) (IEA, 2012). Nitrous oxide also takes about a century to leave the atmosphere after it has been emitted. The WDI quotes this measurement in thousand metric tonnes of C_2O equivalent (that is kilotonnes of CO_2 equivalent).

Methane (CH_4)

Methane is a greenhouse gas emitted from the production and combustion of coal, production of natural gas and human activities. It can also result from transportation activities and certain agriculture practices (EPA, 2017). Methane is a byproduct of the extraction and processing of natural gas and well as the decomposition of waste. Methane is a vital GHG to consider because its impact is about 34 times greater than that of CO_2 compared over 100 years (IPCC, 2013). It is measured in kilotonnes of CO_2 equivalent.

4.3.2 Independent/Explanatory Variables

Lagged Dependent Variable

First of all, it is salient to include the lagged dependent variable because it goes a long way to affect the results. The inclusion is informed by theory that the current level of emissions in the atmosphere is highly dependent on previous level emissions. That is to say, CO_2 emitted today stays in the atmosphere for over a century and leaves behind 20% behind as it finally evacuated the atmosphere (Forster *et al.*, 2007). Also, nitrogen oxide emitted today evacuates the atmosphere after about a century. Arellano and Bond assert that the inclusion of the lagged dependent variable allows for the capturing of the dynamic effect. The dynamic model specified above permits for the likelihood of the impact of trade on emissions in the previous period (t-1) affects current period (t) emissions. Lieb (2003) argues that income and trade may not instantly have effect on current level emission but rather only a lagged effect on emissions. This variable is therefore relevant, and its omission may result in omitted variable bias rendering our results inconsistent and unreliable.

Real GDP per capita (RYPC)

Real GDP *per capita* is defined as GDP *per capita* at constant 2010 USD and is used as a proxy for economic growth. This study employs real GDP *per capita* sourced from WDI and measured in real dollars, that is 2010 constant USD. This variations in the differences in real GDP *per capita* from country to country serves as a basis for differences in growth between countries.

Thus, this variable is used to infer the inverted U-shaped relationship between environmental quality/pollution and growth. Real GDP *per capita* captures the technique-scale effects - this follows and is consistent with the EKC literature-(Cole & Elliot, 2003).

The square of the real GDP *per capita* captures the scale, technique effects (Doudu, 2019). Grossman and Krueger (1995) postulates that if production mix and techniques of production are constant over time, then the large scale of global economic activity brought about by extraction can in itself alter the techniques of production in such a way that will, in the end, reduce emissions. Given that this argument is true, it implies that the technique and scale effects run in opposing direction and the final impact of real income on the environment is dependent on their relative magnitudes. The scale effect is expected to be positive while the technique effect is negative.

Capital-labour ratio (klr)

The composition effect is represented by a country's capital-labour ratio (Cole & Elliot, 2003). The capital-labour ratio is very crucial in describing patterns of trade in an economy's industrial sector (Kowalski, 2011). Any interference with comparative advantage, for instance, support from government to sectors where there exists comparative advantage would decrease benefits from trade or probably negate it (Deardorff, 2011). Theory posits that capital-intensive production processes are supposed to be more pollution intensive than the labour-intensive process. Therefore, we expect that countries with low klr to experience low pollution relative to those with high klr. The square of the capital-labour ratio is included in the model to capture the diminishing returns effect of capital accumulation.

Relative real GDP per capita *(rRYPC)*

Relative real GDP *per capita* is expressed as the real GDP of a country (say country *i*) expressed as the world's average (Cole and Elliot, 2003). The relative real GDP *per capita* helps capture the comparative advantage (Doudu, 2018). This calculation is done by dividing RYPC at a specific time over the world's average. This helps lessen the income disparities between countries, especially developed and developing.

$$World's\ average(Y_{wt}) = \frac{\sum_i^n \sum_{t=1980}^{2017} RYPCit}{N}$$

$$\text{Relative real GDP } \textit{per capita} \text{ (rRYPC)} = \frac{\sum_i^n RYPC_{it}}{Y_{wt}}$$

$\sum_i^n RYPC$ = real income *per capita* from country i to the nth country at a specific time t.

Relative capital-labour ratio (rklr)

The relative capital-labour ratio is the klr of a country expressed as the world's average. The relative capital-labour ratio is calculated as capital (K) divided by Labour (L) of a country. Gross capital formation is used as a proxy for capital and total population used as labour. WDI defines gross capital formation as additions to a country's fixed assets plus changes in the level of inventory. Fixed assets include infrastructure developments, value additions to land, plant and machinery. Inventories comprise stocks of goods kept by firms in the quest to cater for unforeseen and unexpected circumstances in production. The data is sourced from WDI and constant at USD 2010 constant. The square of the RK/L ratio is included to capture the comparative advantage of countries (Managi *et al*., 2009). This study calculates $rklr_{it}$ as below;

$$rKLR = \frac{\sum_i^n klr}{Aklr}$$

where Average Capital labour ratio $(AKLR) = \sum_{i}^{n} \sum_{t=1980}^{2017} \frac{klr_{it}}{n}$

n = the total number of countries

$\sum_{i}^{n} klr$ = summation of capital-labour ratio from country i to the nth country at a specific time.

Trade openness (top)

Trade openness often referred in most literature as trade liberalization is the extent to which an economy is opened to the international market in terms of exchange of goods and services. It is important however, to note that trade liberalization is not exactly trade openness. While trade liberalization is the removal of trade barriers and distortions, trade openness measures the intensity of trade. Thus, trade liberalization can lead to openness. Trade openness plays a significant role in the internationalization of an economy's market, hence a potential variable for economic growth, albeit its possible implications on the environment. Similar to FDI, the effect of trade openness on the environment is ambiguous, usually linked to the trade policies of countries involved, particularly developing and emerging economies. The effect of trade, specifically for developing countries, can be highly linked to their imports. Developing countries are known to import second-hand goods which are not environmentally friendly or pollution-prone.

The effect of trade openness on the environment has been examined by several researchers and the results mixed-positive, negative and no significant relationship. Several authors, such as Bernard and Mandal (2016); Cole & Elliot (2003) and Managi *et al*., (2009) found that trade openness increases CO2 emissions. Jafari *et al*., (2017) found no significant effect of trade on the environment. On the other hand, Dean (1999) found a negative effect on the environment.

For this study, trade openness is measured as the sum of exports and imports as a percentage of GDP. The ratio of trade to GDP has increased for most trading nations and is as a result of globalization and removal of barriers. Trade openness can influence the environment through scale, technique and composition effects.

Foreign Direct Investment (FDI)

Foreign direct investment plays a significant role in economic growth and subsequently, environmental quality. This, therefore, explains why it is salient for it to be controlled; the exclusion of this variable from Managi *et al*., (2009) makes their results inconsistent and unreliable. Trade and foreign direct investment impact the environment mainly through economic growth, and subsequently level of income of an economy (Frankel, 2009), and these effects on the environment can be either beneficial or detrimental. Frankel (2009) also suggests that the most substantial effects of trade are via the economic growth channel.

Environmental arrangement and Institutional arrangement (ER)

In this paper, we modify the environmental quality equation by introducing the ER_{it} and taking out the international protocol dummies because this study is interested in knowing how differences in environmental quality may be accounted for by environmental policy and institutions. Also, the dynamic process is catered for by the lagged dependent variable, and therefore, there is no need to include these variables as purported by Managi *et al*., (2009). There exists extant literature which has argued the environmental regulations and institutional arrangement plays a significant role in the trade-environment nexus (McCartney & Adamowicz, 2005). The ER variable indicates the direct impact of environmental regulations and institutional arrangement on environmental quality. The world bank defines this variable as an index that is meant to ascertain the extent to which environmental policies foster the protection and sustainable use of natural resources and the management of pollution. The World bank codes this index on a scale from one (1) to six (6); one representing weakest environmental regulation and institutional arrangement and six representing tightest environmental regulations and institutional arrangements. It is expected that the laxer regulations and weak institutions are, the more pollution they are likely to experience, and therefore, the sign is expected to be positive.

Population growth per total land size (PGPLS)

Population growth of a country defines the rate of change of the size of the total number of people living in the country over a period of time. It is the percentage change (decrease or increase) in the total population over time. Review of literature show evidence of adoption of total population and in most cases, population growth (Antweiler, 2003) as an internal source of environmental impact. In a panel study such as this, there is the possibility of relativity bias in using total population and also population growth as a control variable given the different land sizes of countries.

This study, therefore, examines the effect of population growth on the environment by taking into consideration the total land size/space of each country. Hence, the rate of growth of a country's population per its total land size is employed as a control variable in this study. A higher PGPLS is an indication of near capacity in terms of the number of people increasing against a fixed land size, all things being equal, and: this can have negative implications for the environment. Conversely, a relatively low PGPLS, means their ratio of human to land size is small, hence, better utilization of scarce resources, in this case, land. In other words, the quest to meet the economic demands of an increasing population relative to a given land size breeds unhealthy competition which could result in overexploitation of limited land and its component resources. A relatively increasing population per land size is tantamount to increasing human activities which put pressure on productive activities that could have detrimental impact on the environment. This, study therefore, expects a positive effect of population on the emissions.

Real GDP per square Kilometer (RYPSK)

The data for the variable real domestic product per square kilometer is obtained from the WDI database. The variable is used to measure the scale of economic activities. It is computed by dividing real income in a particular year (t) for a country (i) by the total land area of that country. RGDPpK captures the trade-induced scale effect on the environment. According to Antweiler (2001), the scale effect is expected to be positive: thus, as trade increases, emissions also increase. Hence the coefficient of RYPSK is expected to be positive. With trade openness, countries with high relative capital-labour ratio (capital-intensive) ratio are likely to attract pollution-intensive production and hence increase in emissions (Managi *et al*., 2009). However, some argue that given trade openness, the lax environmental policies in low-income or labour-abundant countries would attract pollution- intensive firms and hence increase emissions.

4.3.4 Explanation of interactive terms

ER, (top)

Another modification to the model adopted from Managi *et al*., (2009) is the introduction of the interaction term between environmental regulation and trade openness. This is because the incomes of countries can dictate their willingness to open up to trade and thereby affect their regulation and eventually affect emissions, Countries with low *per capita* income in a bid to grow and also attract foreign investment are more likely to lax their environmental regulation. Low-income countries in fear of losing out of international competitiveness are also more likely to have less stringent environmental policies. This might be to remain relevant in the international market.

On the other hand, for low-income countries, trade is a possible avenue to enhancing consumer welfare as it makes available both environmental and consumer goods. As trade opens, the welfare of low-income countries is enhanced and therefore making it more likely for them to demand more environmental good than bad, which with time becomes the norm or standard. This captures the additional scale and technique effect.

Relative[1] *real GDP* per Capita *and Trade Openness (Haven)*

Haven is an interaction term that captures the combined effect of relative real GDP *per capita* and trade openness. This variable is employed in the study to help determine the existence of pollution havens in the countries under study. The pollution haven hypothesis argues that developing countries are likely to attract pollution-intensive industries because of their lax environmental regulations. Thus, this variable would allow for us to authenticate this claim and also determine whether developed countries attract only environmentally-friendly industries. Thus, the coefficient of this variable is expected to be positive for developing countries and negative for developed countries. That is, developing countries are likely to be more polluted than developed ones.

[1] Relativity included to emphasis comparison

RYPC, (rKLR)

The real GDP *per capita* is interacted with the capital-labour ratio to ascertain the impact of capital accumulation on real income *per capita* and hence, pollution emission. In theory the impact of capital on the pollution is dependent of the techniques of production in a country. However, since there are variations in income across countries, producer prices and therefore production techniques and the composition of their outputs vary. Also, the impact of increased capital accumulation on the composition of production output and thus pollution differs across country to country. This captures part of the composition effect and could be positive or negative (Antweiler *et al*., 2001).

RKLR (top)

This is an interaction between relative capital-labour ratio and trade openness. A country specializes in what they have a comparative advantage. A country with capital-abundance will specialize in the production of capital-intensive goods. A country endowed with more labour than capital will also specialize in labour-intensive production (Cole & Elliot, 2003). Doudu (2019) suggests that countries with a comparative advantage in capital-intensive production implement stringent rules while labour-intensive countries enact weak rule.

Table 4.1: Description of Study Variables and Expected Signs

Variable	Description	Expected Signs
lnE_{it}	*Log of CO_2, N_2O & CH_4 emissions for country i at period t, dependent variable. The lagged term is included to cater for the dynamic process.*	+/-
klr_{it}	*Capital-labour ratio for country i at time t. This captures the factor endowment or otherwise the composition effect. The squared term is included to account for the diminishing returns on capital accumulation.*	+/-
$rKLR_{it}$	*Relative capital labour ratio calculated as K/L ratio of country i at period t to the world's average. It captures the comparative advantage.*	+/-
$RYPC_{it}$	*Real GDP per capita of country i at time t. Its quadratic term is included to capture the EKC or scale, technique effect.*	+ & -
$RYPC_{it}$ $*klr_{it}$	*Interaction of capital-labour ratio and real GDP per capita. This captures part of the composition effect.*	+/-
top_{it}	*Trade openness measured as (export + imports)/GDP of country i at time t.*	+/-
$rRYPC_{it}*top_{it}$	*This represents an interaction between relative real GDP per capita and trade openness (pollution haven effect).*	+/-
$RKLR_{it}*top_{it}$	*This represents an interaction of trade openness with country i's relative capital-labour ratio. It captures the factor endowment effect component.*	+/-
$rKLR_{it}*top_{it}$	*this is an interaction of trade openness and relative capital ratio*	+/-
FDI_{it}	*This variable captures how the environment is impacted by foreign direct investment*	+/-
ER_{it}	*this variable captures the direct impact of environmental arrangement/policies and institutional arrangement on environmental quality.*	+/-
ER_{it} $*top_{it}$	*an interaction between trade openness, and environmental arrangement and institutional arrangement. This captures the addition scale and technique effects.*	+/-
$PGPLS_{it}$	*Population growth per total land size* .	+
$RYPSK_{it}$	*Real income per square kilometer. It captures part of the scale effect.*	+

Source: Authors Construction, 2019.

4.4 Estimation Strategies

4.4.1 Panel Unit Root Test

As part of our empirical estimation to determine the long-run relationship between the variables, we pre-test whether our variables are stationary. Testing for unit root would also help us with the panel cointegration procedure. We, therefore, conduct a unit root test on the emission variables (CO_2, N_20, CH_4) trade, income, its squared term and the dynamic process depicted by the lagged dependent variable. To test the unit root, the literature presents several methods including the Levin–Lin–Chu (2002), Harris–Tzavalis (1999), Breitung (2000; Bruiting and Das 2005), Im–Pesaran–Shin (2003), Fisher-type (Choi 2001), the Hadri (2000) Lagrange multiplier (LM) test. While the latter has the null hypothesis that all panels are trend stationary, the rest has the null hypothesis that all panel contain unit root. Of these, the Im-Pesaran-Shin (IPS) and Fisher-type (FT) is appropriate for unbalanced panel data and appropriate for a small-time dimension.

We, therefore, employed both IPS and FT test for unit root to confirm the existence of stationarity because it appropriate for our panel data. We find that our model is not stationary at levels I (0) except for nitrous oxide. However, all the variables are stationary at first difference I (1), that is after the first difference. Hence emissions, trade and income for our study are stationary at levels and first difference. Therefore, we conclude that our series is mixed (*I(0) & I(1)*).

4.4.2 Panel Cointegration Test

It is essential to check for cointegration to restore the dynamic nature of the model since some of the variables are non-stationary at levels. With stationarity at first difference confirmed that is non-stationary at levels and before the estimation of equation (6) we find that income, trade, and emission may be cointegrated implying a long-run “wandering” relationship between the variables of interest. We conduct a test for cointegration to confirm whether there exists a long-run relationship between the series. We employ the Kao (1999) ADF-tests, which permits for cross-sectional dependence and it is also recommended for small *T* panel data (Pedroni, 2001). We go on to estimate the long run coefficients with the Dynamic OLS procedure. Finally, equation (6) is estimated using system GMM with the standard errors corrected for heteroskedasticity and autocorrelation.

4.4.3 General Methods of Moments

There exist several methods to estimate the empirical model, such as the is Ordinary Least Squares (OLS), Generalized Least Squares (GLS), Fixed and Random effects and the General Methods of Moment (GMM). OLS is not appropriate because first of all, the time series data against the pooled cross-section does not allow us to estimate equations over a long period for several countries. Secondly, OLS yields biased and inconsistent results in the presence of unobserved heterogeneity. Thirdly, there may be the presence of autocorrelation and heteroskedasticity which may bias the results if OLS if used. Im *et al*., (2002) emphatically state that the OLS in a nut-shell produces extremely misleading results for a study such as this.

The likely problem of estimating our model with the fixed effect (FE) treatment is that it may lead to inconsistent estimates due to the problem of autocorrelation resulting from the employment of the lagged dependent variable as a regressor (Nickel, 1981; Gujarati, 2014). This makes the fixed effect estimation procedure asymptotically insufficient in the presence of autocorrelation. Also, given an estimation with a large number of entities (N= 54 countries) and small-time dimension (t=34 years), the fixed effect treatment may result in inconsistent estimates (Jafari *et al*., 2017). Frankel and Rose (2005), Managi *et al*., (2009) further argues that we cannot treat trade and income as strictly exogenous variables. This is to say that the causality may run in both directions; from trade to income and vice versa and thus may be correlated with the error term. Hence, OLS and FE parameters may no longer be unbiased and inconsistent (Pearsaran *et al.*, 1999).

There also is the presence of massive variability in the dataset used in this study stemming from the regions considered. SSA houses the world's lowest-income countries even though there are some extreme exceptions such as Sao Tome and East Asia on the other hand houses some of the world's high-income countries such as Hong Kong and therefore, the GLS method may not be appropriate for a study like this because the data is characterized spatial dependence and spatial heterogeneity (Arbia & Paris, 2005) and it may not properly capture these dynamics. Even though the GLS estimator is argued to be robust, the system GMM remain relatively superior in the presence of spatial heterogeneity and spatial dependence.

In investigating a dynamic economic relationship such as this, random effects or fixed effect could be employed to obtain consistent results but with the introduction of the lagged dependent variable, the system General Moments of Method (GMM) is the most appropriate. Some econometricians (Hsiao, 1982, Arellano & Bover, 1995; Blundell & Bond 1998) argue that in order to effectively control for these issues there is a need to adopt a GMM-type moment conditions method and system GMM estimators. It overcomes the issue of endogeneity and also accommodates for the dynamic nature of the model by including appropriate instrumental variables (Bond, Hoeffler & Temple, 2001). GMM estimation also evades the bias arising from the inclusion of the lagged dependent variable as a regressor.

The problem of endogeneity resulting from the inclusion of the lagged dependent variable is commonly solved in the literature with general methods of moments (difference or system). The

GMM results are consistent and efficient estimates in a situation where the data suffers from heteroskedasticity. GMM allows for modelling across entities and allows for any country-specific effect to be controlled for. It also ensures any potential endogeneity regressors may have is controlled for. Managi *et al*., (2009) postulate that the dynamic GMM is necessary for the correction of serial correlation and to analyze for both short and long-term of trade openness on the environment. Also, the GMM is appropriate for panel data with relatively small-time dimensions, as compared to the number of cross sections (Roodman, 2009). It is essential to note that the system GMM may not be appropriate for large cross-section and large time periods data.

The difference and system GMM estimators are powerful techniques to estimate dynamic panel data models with autoregressive processes for small time dimension and large N panels. We adopt the system GMM instead of the difference GMM because they differ in several ways and may also indicate varying results. Foremost, Blundell and Bond (2000) criticized the difference GMM for not producing appropriate and satisfactory results and also suffers from large sample bias and results in very low precision. They argue that these issues may results from weak correlation between current levels of income, capital and emissions to the lag of each variable. In addition, Acemoglu *et al*., (2008) have shown that the difference GMM estimator performs poorly when the dependent variables are persistent. They, therefore, recommend the system GMM because of its superiority to the difference GMM indicated above.

The sys-GMM uses the lagged difference to estimate the equation in first-difference and eventually at levels and produces a less bias compared to the diff-GMM. It reports the highest precision of estimates, and it can to correct for unobserved country heterogeneity, endogeneity, omitted variable bias and measurement errors (Pesaran *et al*., 1999). It also improves the precision and the efficiency of the lagged dependent variable ability as an instrument than in the diff-GMM (Greene, 2003; Halkos & Polemis, 2017)

4.4.4 Causality

Decompositions are not enough to tell us about causality; the breaking down of the various effects does not provide us a clear picture of the causal relationship between trade and environment. In the trade literature, it is challenging to come across a paper that focuses on assessing the causal relationship between trade and the environment. For most researchers, there exists a causal theory and therefore, do not see the need to confirm it. Yet, it important to explicitly assess this relationship so as to confirm whether this theory is consistent in these regions considered. This paper does extensively assess the causal relationship between trade and the environment but goes a great length to employ an already establish procedure to assess it. This paper finds that the relationship between trade openness and emission is unilateral.

Theoretically, causality can be modelled as below:

$$\Upsilon_t = \alpha_0 + \sum \alpha_i \Upsilon_{t-i} + \sum \beta_i \chi_{t-j} + \varepsilon_i \qquad (9)$$

$$\chi_t = \alpha_0 + \sum \alpha_i \Upsilon_{t-i} + \sum \beta_i \chi_{i-t} + \mu_i \qquad (10)$$

Where χ and Υ are the variables under consideration, α and β are parameters and μ and ε are error terms.

t-i is the lag while t-j is the lag period.

Empirically, we employed the panel causality test introduced by Elena-Ivona Dumitrescu and Christophe Hurlin (2012) based on the Engel and Granger (1969) to assess the causal relationship between trade and emission. We employ this test because of the heterogeneous nature of our panel data. Below is the underlying regression of the extension of the Granger test by Dumitrescu and Hurlin (2012) test designed to assess causality in panel data.

$$\Upsilon_{i,t} = \alpha_i \sum_{k=1}^{K} \beta_{ik} \Upsilon_{i,t-k} + \sum_{K=1}^{K} \Upsilon_{ik}\, \chi_{i,t=k} + \varepsilon_{i,t} \quad (10a)$$

Where ϒi,t and χi,t are the observation of two stationary variables for individual I in period t. K is the lag order assumed to be similar for all panels. The null hypothesis (H_{1o},H_{2o}) assume no causality relationship for any of the units of the panel. This assumption is referred to as the Homogeneous Non-Causality (HNC) hypothesis.

The alternative (H_{1a}, H_{2a}) is referred to as Heterogeneous Non-Causality (HENC) hypothesis, which assumes causality for at least one of the panel unit.

Hypotheses

i.$\boldsymbol{H_{1o}}$**:** χ does not Granger-cause ϒ

$\boldsymbol{H_{1a}}$ **:** χ does Granger-cause ϒ for at least one panel.

ii.$\boldsymbol{H_{2o}}$**:** ϒ does not Granger-cause χ

$\boldsymbol{H_{2a}}$**:** ϒ does not Granger-cause χ for at least one panel.

According to the definition of Granger causality, we fail to reject $\boldsymbol{H_{1o}}$ if

$$\alpha_i = \alpha_2 + \alpha_3 + \alpha_{t-j} + \cdots + \alpha_j = 0 \quad (11)$$

and accept $\boldsymbol{H_{2o}}$ if

$$\beta_1 = \beta_2 + \beta_3 + \beta_{t-j} + \cdots + \beta_j = 0 \quad (12)$$

The direction of causality is therefore presented as:

If equation (11) holds and equation (12) does not hold then we say χ is Granger caused by Υ and therefore the direction is unity. Thus, causality runs from Υ to χ ($\Upsilon \rightarrow \chi$).

If equation (12) holds and equation (11) does not hold then χ is Granger caused by Υ and also unidirectional ($\chi \rightarrow \Upsilon$).

If both equation (11) and (12) holds then χ are independent, implying no relationship between them.

If both equations (11) and (12) does not hold the Υ is Granger caused by χ and χ is Granger caused by Υ and therefore the direction is bidirectional. This is to say that causality runs in both direction ($\Upsilon \leftrightarrow \chi$)

CHAPTER FIVE

RESULTS AND DISCUSSION

5.0 Introduction

This chapter presents the study results and discussion of findings therein. The findings from the study are discussed in relation to reviewed literature and in line with economic theory. Presentation of study findings are organized under descriptive statistics, unit root test, test for cointegration, causality, and the empirical results which follow from the empirical model of the study.

5.1 Descriptive Statistics of Data

It is crucial to examine the summary statistics of the study variables before analyzes. This is with the aim of observing the data and also helps present to the reader the variability and distribution of the data. The summary statistics of the study variable is therefore presented in table 5.1. below. The table reports for SSA and EA as well as the overall, the number of observations, mean, standard deviation, minimum and maximum values of the variables employed.

Relative to SSA, Ease Asia reports a higher emission on average for all emission types considered in this study. Average emission of N_2O, CO_2, and CH_4 for EA recorded approximately 8.29, 11.46, and 8.48 kilotons respectively relative to 7.66, 7.30, and 8.37 kilotons for SSA. EA recorded the highest emission of all three pollutants with maximum emission of 13.28kt, 16.14kt, and 14.38kt of N_2O, CO_2 and CH_4 respectively, as against 12.06kt, 13.13kt, and 12.15kt maximums for respective pollutants for SSA. This is against the fact that only a few (7) countries from that region compared to the Sub-Sahara African (47) countries considered. Carbon dioxide is the highest average overall emitted GHGs from East Asia with a mean of 11.4628kilotons. However, methane is the highest overall average gas emitted.

The average of trade openness is highest for East Asia and the lowest for SSA. The average overall trade openness is 0.7 with a maximum value of 4.34 and a minimum of almost zero. The sample average of the relative income is highest for East Asia as compared to SSA; however, the average relative capital-labour ratio for SSA to East Asia.

ER differences serve as a crucial source of comparative advantage. That is, the PHH postulates expansion of pollution-intensive industries in countries with lax ER and contract in countries with relatively stringent ones. The average strength of both East Asia’s environmental regulation and institutional arrangement index (3.15) and Sub-Saharan Africa are (3.06) is weak compared to the upper limit of 6.

Table 5.1: Descriptive Statistics of Study Variables for SSA, EA & Overall

Variable	Region	Obs.	Mean	Std. Dev.	Min	Max
lN_2O	SSA	1288	7.659849	2.155379	1.648349	12.05945
	EA	195	8.29052	3.125036	1.759632	13.28306
	Overall	**1,483**	**7.742776**	**2.314786**	**1.648349**	**13.28306**
lCO_2	SSA	1,364	7.301469	1.699907	3.496598	13.12857
	EA	197	11.4628	2.689732	6.597691	16.14687
	Overall	**1,561**	**7.826634**	**2.311828**	**3.496598**	**16.14687**
lCH_4	SSA	1,284	8.37149	1.924282	2.693498	12.15308
	EA	196	9.477536	2.673386	4.183937	14.37643
	Overall	**1,480**	**8.517966**	**2.072463**	**2.693498**	**14.37643**
RYPC	SSA	1,405	7.09001	1.401353	5.097567	13.52338
	EA	198	9.317676	1.327505	6.289142	11.18696
	Overall	**1,603**	**7.365167**	**1.57333**	**5.097567**	**13.52338**
rRYPC	SSA	1,405	1.078133	6.12097	.0111618	43.96564
	EA	198	1.349612	1.071873	.0415188	4.135328
	Overall	**1,603**	**1.111666**	**5.743246**	**.0111618**	**43.96564**
Klr	SSA	968	5.825807	3.176419	-15.8654	19.42877
	EA	167	8.439667	.8892911	5.802956	9.602322
	Overall	**1,135**	**6.210401**	**3.09478**	**-15.8654**	**19.42877**
Rklr	SSA	974	1.785088	9.461752	-3.33e-13	53.95647
	EA	167	.2594293	.8585783	.0002306	6.326509
	Overall	**1,141**	**1.561788**	**8.76405**	**-3.33e-13**	**53.95647**
Top	SSA	1,038	0.6747407	0.3799696	0.0462638	2.429829
	EA	145	1.277914	1.125003	0.1435454	4.344694
	Overall	**1,183**	**0.7486715**	**0.5656984**	**0.0462638**	**4.344694**
FDI	SSA	1,293	0.3859105	1.786372	-11.48545	5.086508
	EA	166	.2082608	2.264156	-7.233755	4.069347
	Overall	**1,459**	**.3656981**	**1.846925**	**-11.48545**	**5.086508**
PGPLS	SSA	1,478	0.0001847	0.0006744	-0.00564	0.0094272
	EA	231	0.015778	0.0422038	-.0001878	.2132724
	Overall	**1,709**	**.0022924**	**.0163916**	**-.00564**	**.2132724**
RYPSK	SSA	1,371	10.71928	1.894096	7.48213	17.93409
	EA	198	15.30325	4.077286	7.594153	21.0394
	Overall	**1,569**	**11.29776**	**2.746226**	**7.48213**	**21.0394**
ER	SSA	493	3.069168	.5691088	1	4
	EA	13	3.153846	0.3755338	2.5	3.5
	Overall	**506**	**3.071344**	**0.5648701**	**1**	**4**

Source: Author's Construction s

5.2 Results of Stationary Test

For efficient estimation of our model, to avoid spurious regression and also to investigate the possibility of panel cointegration, a unit root test is conducted on our variables of interest. Table 5.2 reports both the IPS and Fisher-type tests for unit root for the variables at levels and after first differencing. As indicted in the table, Fisher-type statistics only show stationarity for four out of nine variables while the IPS statistics shows how stationarity of only one (N_2O) variable. However, with a high level of significance (1%), all the variables turn to be stationary after first difference for both IPS and Fisher-type tests, exhibiting an I (1) process. The IPS statistics reported is the statistic, *Zt-bar* (no lags) and the *Wt-bar* (lags included). We also report only the inverse normal Z-statistics because Choi (2001) recommends using it in applications since it gives the best trade-off between size and power. Values of some of the variables are missing for the IPS test because the IPS test requires a panel of not less than ten values to run.

Table 5.2: Panel Unit Root Test Results

Panel	*Ho: All Panels contain unit roots*			
	Level		**First Difference**	
	IPS Stats.	*FT Stats (Inverse normal, Z-stats*	*IPS Stats.*	*FT Stats (Inverse normal, Z-stats*
CO_2	-	3.6558	-	-32.0112***
Lag of CO_2	-	0.5637	-	-18.9273***
N_2O	-1.5109**	-2.1532**	-21.7134***	-36.342***
Lag of N_2O	1.0167	-1.7633**	-22.9645***	-20.7811***
CH_4	-2.4336	-2.4336***	-19.2764***	-37.1229***
Lag of CH_4	-0.4876	-2.3829***	-23.0978***	-21.3431***
RYPC	-	3.9215	-16.9241***	-22.9782***
Square of RYPC	-	1.9613	-14.8480***	-33.5894***
Top	-	-19.9284	-	-19.9284***

Source: Author's estimation from data, 2019 (Stata Version 15.0)

*, **, *** denote 10%, 5%, & 1% level of significance respectively

5.3 Results for Cointegration Test

To efficiently estimate the long run relationship of *I (1)* series we check for the cointegration relationship between CO2 emissions; CH4 emissions, income and trade openness. We employed the Kao (1999) test for cointegration and the Dickey-Fuller (DF) statistic allows for us to reject the null hypothesis of no cointegration at 1% and 5% level of significance and confirm that the variables are cointegrated. Table 5.3 presents the result for the Kao test for panel cointegration, separately for the three emission variables and trade and income. A probability value of less than 1% for all three sets of relationships, show a high level of significance, hence, refusal to accept the null hypothesis of no cointegration. The implication is that all the panels are cointegrated, showing the presence of long-run association among the variables of the three sets of model or relationships. (CO_2. trade, income), (CH_4, trade, income) and (N_2O, trade, income). It can, therefore, be inferred that a regression between emissions, trade and income is not spurious as there exist some stable long-run relationship between these variables.

Table 5.3: Koa Test for Panel Cointegration Test Results

Variables	Hypothesis	DF Statistic	P-Value
CO2, Trade, Income		**-2.4146*** **	0.0079
CH4, Trade, Income	*Ho: No Cointegration* *Ha: All Panels cointegrated*	**-5.6774*** **	0.0000
N20, Trade, Income		**15.0682*** **	0.0000

Source: Author's estimation from data, 2019 (Stata Version 15.0)
Note: **, **, *** denote 10%, 5%, & 1% level of significance respectively*

5.4 Panel DOLS Estimation Results

This test follows our second objective to determine the long-run relationship between trade openness and emissions**.** For a panel framework, in the presence of cointegration, several estimation procedures can be used including; OLS, Fully Modified OLS (FMOLS), Dynamic OLS (DOLS) and Pooled Mean Group (PMG). Both FMOLS and DOLS controls for endogeneity of regressors and serial correlation that are normally present in long-run relationships as compared to the standard pooled OLS. Kao and Chaing (2000) argues that the PMG exhibit small sample bias.

This study employs the DOLS estimator because it fits well with the data, it outperforms the FMOLS and PMG and it controls for small sample bias. Also, the FMOLS is not appropriate for this study because it requires that all variables are integrated of the same order (the variables of this study are integrated of mixed order) and that the regressors should not be cointegrated.
DOLS, in contrast to other estimators, does not require that all individual series be integrated of order one, that is, I (1). It can be applied to series with mixed order of integration as our data presents (Stock & Waston, 1993).

The DOLS estimator proposed by Kao and Chiang (1998, 2001) is an extension of Stock and Watson's (1993) estimator. In order to obtain an unbiased estimator of the long-run parameters, DOLS estimator uses parametric adjustment to the errors by augmenting the static regression with the leads, lags, and contemporaneous values of the regressors in first differences. The results are shown in table 5.4.

Table 5.4: Dynamic OLS for long-run relationship

Carbon dioxide	Nitrous dioxide	Methane
0.1159	-1.4989***	-1.1857***
(-0.1617)	(-0.0993)	(0.0813)

Source: Author's estimation from data, 2019 (Stata Version 15.0)
*, **, *** denote 10% 5% & 1% level of significance respectively.

The results from Table 5.4 shows that emissions and trade openness seem to have long-run relationship and the sign and significance depends on the emission data considered. We find that there exists no significant long run relationship between carbon dioxide emissions and trade openness. However, from the estimation results indicate that nitrous oxide and methane has a significant, stable and negative long run relationship. Therefore, in the long run trade openness can lead to a fall in the emission of nitrous oxide and methane by -1.4989% and -1.1857% respectively.

Specifically, we find that in the long-run, a unit increase in trade openness would cause a fall in the emission of nitrous oxide and carbon dioxide by 149 kilotonnes and 118 kilotonnes respectively. There is therefore a long-run relationship between trade openness and emissions excluding carbon dioxide as our study shows.

5.5 Causality Test Results

With cointegration relationship established, it becomes necessary to ascertain the causal relationship between emissions and trade openness. To ensure that the test statistic asymptotically converge to a normal distribution, we restricted our data to conform to the condition where the number of years was greater than five plus two times the number of lags $(T_i>5 + 2Ki)$. The Z-bar tilde test statistics with its corresponding p-value is reported because according to Dumitrescu and Hurlin (2011), it substantially augments the power of non-causality tests even when N is very small. This test statistics is the cross-section average of the individual average Wald statistics associated with the standard Granger Causality tests on single time series. Table 5.5 indicates a unilateral direction of causality of emission data and trade openness for CO_2 and also a unidirectional relationship of causality from trade to N_2O and CH_4.

Intuitively, table 5.5 suggests that the past values of trade openness can be used to predict the current values of carbon dioxide emission, but the present values of carbon dioxides cannot be used to predict current values of trade openness, indicating a unilateral relationship. In addition, past values of nitrous oxide and methane predict current values of trade openness, but the past values of trade fail to predict the current values of nitrous oxide and methane. This also confirms a unidirectional causality.

Table 5.5 reports results for *K=2* and suggest that at least of the subgroups of the panel data on CO_2 Granger-causes trade openness at 5% level of significance. The test statistic is compared to the bootstrap (1000 replications) critical values of the study of Dumitrescu and Hurlin (2012) and conclude that these tests statistics are significant.

Table 5.5: DH Panel Causality Test

Ho: Y does not Granger-cause X					
Emissions (CO_2, N_20, CH_4) to trade openness			*Trade openness to emissions (CO_2, N_20, CH_4)*		
Tests	**Z-bar Stats.**	**P-value**	**Tests**	**Z-bar Stats.**	**P-value**
CO_2→ top	5.0248 ***	0.0000	top→CO_2	0.2775	0.7814
N_20→ top	0.4124	0.6801	top→N_2O	2.4457**	0.0145
CH_4→ top	-0.1323	0.8948	top→CH_4	3.4100***	0.0006

Source: Author's estimation from data, 2019 (Stata Version 15.0)
, **, ** denote 10% 5% & 1% level of significance respectively.

5.6 System GMM Estimates

This section presents the system GMM estimates and discussion for all the three emission variables. The validity and reliability of our model is confirmed with Hansen, AR (1) and AR (2) tests. The robust standard errors are presented in parentheses with *, **, and *** represent 90, 95 and 99 per cent confidence intervals respectively.

Tables 5.6, 5.7, and 5.8 present the results of the Arellano-Bover/Blundell-Bond system GMM estimates for the study models with CO_2, N_2O, and CH_4 emissions as dependent variables in respective tables. There are differences among the results reported depending on the dependent variable. The significance of the lagged dependent emissions for our estimation depicts that the dynamic model is appropriate. Hence, this suggests that changes in the current levels of the independent variable will affect changes in the future levels of emissions. Thus, there exist short run and long run relationship between trade and emissions. This system estimation passes the Hansen test of valid overidentifying restrictions. The AR (2) test shows no statistical significance with implication of no serial correlation between the error term and the second and deeper lags of emissions. This is to say our instruments are exogenous and our results are valid and reliable. The system GMM technique employed also ensures that our standard errors are robust.

Four separate models are presented in the tables 5.6, 5.7, and 5.8 purposely to capture the various components of the main model (model 4). Model 1 present the EKC with income and its squared term. Model 2 present the results with environmental regulation and its interaction with income and trade openness. The composition effect is partially captured in Model 3 with the inclusion of the capital-labour ratio and finally, Model 4 is the fully specified model in equation (6).

5.6.1 Estimates of model with Carbon Dioxide (CO_2) as dependent variable[2]

From table 5.6, the lag of carbon dioxide is shown to be highly significant (1 per cent) and show a positive relationship with carbon dioxide for all the four models. Intuitively, increases (decreases) in carbon dioxide emission results in increases (decreases) in future levels of emission. The plausible explanation is that past decreases in carbon emission would increase future desire for environmentally friendly activities or production methods, resulting in subsequent decreases in emission. Some explanatory variables influence past levels of emission, hence, Forster *et al*. (2007) argued that the significance of past emissions in explaining present emissions imply that alterations in the explanatory variables such as trade openness can impact on future levels of emissions. of the model. This is consistent with the findings of Managi *et al*. (2009) and Jafari *et al*. (2017).

In addition, model 1 does not confirm EKC and also insignificant. Thus, RYPC and its square ($RYPC_{sq}$) show the inappropriate signs for the EKC. This confirms a U-shaped EKC rather than the normal inverted U-shaped relationship between emission and income for CO_2 and a possible inverted U-shape relationship between income and environmental quality (negative emission). Income is shown not be statistically significant in models 1, 2, and 3. In model 4 which encompasses all the effects, *per capita* income is shown be statistically significant (at 5%) and with a positive sign. The implication is emission cannot be avoided at early stages of economic growth. This is consistent with the studies of Grossman and Kruger (1993), Cole and Elliot (2003), Tsurmi and Managi (2010), and Omri *et al*. (2015).

By augmenting with environmental regulation (ER) variable, it is evident that ER is statistically significant in model 2 and 4 at 5%, and 10% levels respectively, and with positive

[2] rklr, rRYPC dropped due to collinearity issues

coefficients. Environmental regulations and institutional arrangements play a positive significant role in CO_2 emissions. Thus, a unit increase in the index of ER would increase CO_2 emissions by 142kt in model 3 and 1kt in model 4, thus reduce environmental quality. This results though similar to the results of the study of McCartney and Adamowicz (2005) is contrary to the study of Bernard and Mandal (2016), theory and it is counterintuitive. A higher index of environmental regulation and institutional arrangement should instead decrease emission and thereby increase environmental quality. We are however unable to find a reason for this behavior and may require further investigation. However, the interaction between ER, relative income and trade openness indicate a negative significant relationship. This is to say that given trade openness and a relatively high-income country, weak environmental regulations would lead to an increase in CO_2 emissions. Furthermore, an increase in the index of environmental regulation and institutional arrangement given trade openness would reduce CO_2 emissions by approximately 3.33%.

Table 5.6: Dynamic System GMM Estimation Results for CO_2 Emissions

Variables	Model 1	Model 2	Model 3	Model 4
InE_{t-1}	0.8598526*** (0.0362)	0.8802975*** (0.0283)	0.8846271*** (0.0269)	0.8335021*** (0.0436)
RYPC	-0.00000144 (0.0000)	0.00000445 (0.0000)	-0.00000138 (0.0000)	0.0000687** (0.0000)
RYPCsq	4.02E-12 (0.0000)	4.45E-12** (0.0000)	-3.13E-12 (0.0000)	2.84E-12 (0.0000)
ER		0.07793 (0.0483)	0.1429745** (0.0633)	0.01008653* (0.0580)
ER*top		0.02792 (0.0217)	-0.0911323 (0.06330)	-0.060333 (0.0633)
klr			8.22E-10 (0.0000)	2.68E-09 (0.0000)
klrsq			0.0026652 (0.009324)	0.0094797 (0.0105)
klr* RYPC				7.43E-12** (0.0000)
top				0.4422589** (0.1891)
rRYPC*top				-0.093021 (0.4014)
rRYPCsq*top				-.0039361 (0.0106)
klr*top				-1.40E-08 (0.0000)
klrsq*top				-0.014304*** (0.0041)
rklr*top				0.019118 (0.0319)
FDI				0.0032924* (0.0017)
PGPLS				-434.753 (274.9982)
RYPSK				-0.000000638 (0.0000)
Constant	1.141141*** (0.2712)	0.6725534*** (0.2050)	0.3970095* (0.2176)	0.832423** (0.4064)
Observations	1398	324	314	304
number of countries	54	54	54	54
Hansen Test	0.42	0.592	0.3	0.715
AR (1)	-2.891***	-4.1955***	-4.2052***	-4.1006***
AR (2)	0.74649	0.63091	0.82494	0.75073

Source: Author's estimation generated with Stata Version 15.0. Robust standard error (4 decimal places) in parenthesis.

Note: *, **. *** indicates 10%, 5%, 1% level of significance.

From Model 3 of table 5.6, we unable to confirm a significant relationship between capital-labour ratio and CO_2 emissions but find evidence of positive significant relationship for the squared term. This captures the composition effect. This study does not find evidence that capital accumulation does reduce CO_2 emission. We instead find that it would increase it. This may be due to the fact that both regions under consideration have weak environmental regulation and institutional arrangement index and therefore, weak regulations would lead to detrimental effects of capital accumulation rather than positive effects. This is very evident in most of the SSA countries such as Ghana in this study. From our table, it is apparent that some of the signs change from model to model; this is however due to the sensitivity of the model in general and do not bias our model in any way.

Finally, Model 4 includes trade and all the other regressors of the estimation. We find evidence of a positive significant relationship between trade openness and CO_2 emissions. Results indicate that a percentage increase in trade openness would increase CO_2 emissions by 0.442% at 5% level of significance. The interaction between relative income and trade openness and its squared term captures the so-called pollution haven hypothesis. The study finds that pollution haven plays a role in the emission of CO_2 in SSA and EA. Our findings are consistent with the results of the studies of Tobey (1990), Grossman and Krueger (1993) and Jaffe *et al*. (1995). Their results reported that trade openness, indeed leads to increase in the emission of carbon dioxide.

Bernard and Mandal. (2016) found that FDI played a negligible role in environmental emission, however, our results found FDI to be significant and positively related to CO_2 emissions. This contributes to the technique effect of environmental quality. This is plausible because our sample is dominated mainly by Sub-Saharan African countries which rely heavily on FDI. It is therefore not surprising that FDI which was not factored by studies such as Managi *et al*., 2009 was found to significantly influence CO2. We also found that population growth per square kilometer and land area per square kilometer significantly reduces CO_2 emissions in Sub-Saharan Africa and East Asia.

5.6.2 Estimates of model with Nitrous Oxide (N_2O) as dependent variable

Table 5.7 also containing four different models presents the results for nitrous oxide. Similar to the results for CO_2, the lagged nitrous oxide is statistically significant at 1% level for all the four models. This confirms that the previous levels of emissions have an effect on the present level of emission as hinted by Forster *et al*. (2007). This also confirms the theory that nitrous oxide emitted today stays in the atmosphere for about a century before it finally leaves. This also confirms the specification and the use of a dynamic model is appropriate.

The income and its squared term ascertain the absence of EKC for nitrous oxide. In Model 1 of table 5.7, we find evidence that income and its squared term are statistically significant for nitrous oxide emissions. However, the signs of RYPC and $RYPC_{sq}$ indicates the economic growth does not elicit the expected Kuznets effect on environmental quality for SSA and EA all together, hence, refutes the Environmental Kuznets Curve hypothesis for nitrous oxide. Our results indicate a U-shaped EKC, that is as income grows, nitrous oxide emission begins to fall, reaches a minimum and an increase thereafter. This finding, though counterintuitive is plausible in the sense that increase in income may come with more agriculture practices in the regions considered. This is consistent to theory and the study by (Choi *et al*., 2010). However, model 2, 3 and 4 find statistically insignificant results for the existence of EKC for nitrous oxide emissions.

The environmental regulation and its interaction with income and trade openness in model 2 report negative statistically significant results. It shows that an improvement in environmental regulation and institutional arrangement reduces emission by 0.01%. It also indicates that trade openness can lead to a reduction in nitrous oxide emission given income by 0.03% if institutions are strengthened by a unit. Their coefficients capture part of the scale-technique effect as indicated above. This result conforms to theory and appeals to our a-priori assumptions.

Model 3 which reports the capital-labour ratio captures the composition effect. Capital-labour ratio, its squared term and its interaction with real income *per capita* specifically captures the indirect trade-induced composition effect. We find that the capital-labour ratio and its squared term which is negative and statistically significant supports the theory that accumulation of capital has a diminishing marginal effect on nitrous oxide emissions.

Unlike CO_2 emissions the study did not find that trade openness significantly impacted nitrous oxides emissions. This result is consistent with the study of Antweiler *et al*. (2003) who asserted that trade has a zero effect on emissions. The results of table 5.7 (model 4) do not produce any statistically significant relationship for any of the variables and nitrous oxide emissions.

Table 5.7: Dynamic System GMM Estimation Results for N_2O Emissions

Variable	Model 1	Model 2	Model 3	Model 4
InE_{t-1}	0.877597*** (0.0330)	0.7204332*** (0.0679)	0.6361654*** (0.08288)	0.4628275*** (0.0880)
RYPC	-0.000011** (0.0000)	-0.0000117 (0.0000)	-0.00001 (0.0000)	-0.00000166 (0.0000)
RYPCsq	1.29E-11** (0.0000)	1.50E-11* (0.0000)	1.21E-11 (0.0000)	3.24E-12 (0.0000)
ER		-0.045116** (0.0990)	-0.0303444 (0.1157)	-0.0911309 (0.1759)
ER*top		-0.0645* (0.02010)	-0.0190982 (0.4550)	-0.1203542 (0.1828)
Klr			-2.55E-09 (0.0000)	-3.68E-08 (0.0000)
Klrsq			-0.0398304* (0.02320)	-0.0117047 (0.0320)
klr* RYPC				6.89E-12 (0.0000)
Top				-0.5702914 (0.6250)
rRYPC*top				0.1219231 (0.5028)
rRYPCsq*top				-0.0061478 (0.0174)
klr*top				4.91E-08 (0.0000)
klrsq*top				0.0160239 (0.0174)
rklr*top				-0.0506234 (0.1253)
FDI				-0.0025016 (0.0021)
PGPLS				-5732.045 (4488.1870)
RYPSK				-1.50E-08 (0.0000)
Constant	1.141141*** (0.2944)	2.687528*** (0.6757)	3.692958*** (0.7684)	5.37513*** (0.9401)
Observations	1313	1398	249	241
number of countries	54	54	54	54
Hansen Test	0.42	0.592	0.3	0.715
AR (1)	-4.1234***	-3.2062***	-2.7711***	-2.8817***
AR (2)	2.2899	-1.224	-1.3698	-1.5166

Source: Author's estimation, Stata 15.0. Robust standard error (4 decimal places) in parenthesis.

Note: *, **, *** indicates 10%, 5%, 1% level of significance.

5.6.3 Estimates of model with Methane (MH_4) as dependent variable

Table 5.8 presents the results of the estimate with Methane as the dependent variable. As shown, the Hansen J test and second order AR tests are not significant which is desirable. This shows that our model is devoid of serial correlation and our instruments are valid and appropriate. Similar to the statistical results and directional effect for CO2 and N2O, the lagged value of methane reports a statistically significant result at 1% level of significance for all four models, and shows positive effect. This suggests that previous levels of methane emitted can influence the present level of methane emissions. As Forster *et al*. (2007) postulates, methane emitted presently stays in the atmosphere for a decade or more before it finally disappears.

Model 1 of table 5.8 reports income per capita and its squared term are statistically insignificant to the emissions of methane. The results depict no evidence of the existence of an EKC for methane emissions. This implies that methane emissions in Sub-Saharan Africa and East Asia does not follow an inverted U-shaped pattern where growth in income would lead to increases in its emission, attain a maximum and begin to fall after that.

In Model 2 of table 5.8, even though real income square is significant, its impact is almost negligible. We found that environmental and institutional arrangement (ER) is insignificant unless it is interacted with trade openness where it is statistically significant at 5% and its impact positive. This is to say that with lax environmental regulation, openness to trade will be associated with an increase in methane emissions by 0.06%, thereby reducing environmental quality. The opposite applies for a country with stringent environmental regulation where one would expect the quality of the environment to improve the more opened it is to trade.

Table 5.8 Dynamic System GMM Estimation results for CH4 Emissions

Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**
InE_{t-1}	0.901988*** (0.9020)	0.7788525*** (0.0462)	0.7252611**** (0.0768)	0.4777767*** (0.1094)
RYPC	-0.00000217 (0.0000)	-0.0000185 (0.0000)	-0.0000174 (0.0000)	-0.0000318* (0.0000)
RYPCsq	1.28E-12 (0.0000)	2.32E-11** (0.0000)	2.00E-11* (0.0000)	1.64E-11 (0.0000)
ER		-0.0031127 (0.0656)	-0.191179 (0.0706)	-0.095042 (0.1058)
ER* top		0.0620084** (0.0256)	0.0171342 (0.0336)	0.1252296 (0.1223)
Klr			-1.00E-09 (0.0000)	-4.69E-08 (0.0000)
klrsq			-0.036312 (0.0247)	0.0085808 (0.0256)
klr* RYPC				1.20E-11* (0.0000)
Top				-0.4589026 (0.3490)
rRYPC*top				-1.062004 (1.4181)
rRYPCsq*top				0.0365098 (0.0409)
klr*top				6.27E-08 (0.0000)
klrsq*top				0.0082424 (0.0089)
rklr*top				-0.0798773 (0.1544)
FDI				-0.0005523 (0.0010)
PGPLS				-4462.47 (2879.699)
RYPSK				4.98E-07 (0.0000)
Constant	1.141141*** (0.0053)	2.206202*** (0.5302)	3.041766*** (0.8363)	5.388*** (1.2588)
Observations	1,309	255	245	237
number of countries	54	54	54	54
Hansen Test	0.42	0.592	0.3	0.715
AR (1)	-2.9483***	-2.5363**	-2.2886**	-2.4337**
AR (2)	1.5154	-1.0396	-1.2276	-1.2791

Source: Author's estimation (Stata 15). Robust standard error (4 decimal places) in parenthesis.
Note: *, **, *** indicates 10%, 5%, 1% level of significance.

The study does not find evidence for the theory that accumulation of capital has a diminishing marginal effect on methane emissions. Model 3 of table 5.8 presents statistically insignificant results for capital-labour ratio and its squared term. However, the negative statistically insignificant coefficient of the square term of the capital labour-ratio suggests that methane emissions falls as capital-labour ratio increases.

In Model 4, we find that apart from the lag of emission which is highly significant at 1%, real income per capita and its interaction with capital-labour ratio which are both significant at 1%, albeit negligible magnitudes; all variables including trade openness is statistically insignificant. The results for the interaction between real income per capita and capital-labour ration confirm the factor endowment hypothesis. Thus, with constant income, countries with relatively high capital tend to produce more capital-intensive good which induces methane emission, hence deterioration of environmental quality.

We are uncertain what accounts for the reason why trade openness does not significantly increase or decrease methane emissions. Considering the fact that methane is largely emitted from the agricultural sector which characterizes our sample, we expected trade to significantly affect emissions. This is however, a plausible situation because as reported by EPA (2016), methane is not only via agricultural practices but also through the transportation process of oil, natural gas and coal. This form of methane emissions is highly localized and may not necessarily contribute to the global level emissions. In addition, the coal reserves in the sample regions are in only China, Mongolia, Japan, South Korea and Zimbabwe (World Energy Council, 2019).

5.7 Summary of Results

This section summarizes the chapter which presented the results that answer the objectives of the study. It sought to examine the effect of trade openness on environmental quality with specific reference to carbon dioxide, nitrous oxide and methane have been analyzed and results presented in this section. A maximum of *I (1)* process was observed for the time series properties of the panel using the panel unit root test. The cointegration test also confirmed a long-term association among the panel variables. The Dynamic OLS results depict significant long-run negative relationship between nitrous oxide and methane but not for carbon dioxide.

In addition, the test for causality revealed a unidirectional causality leading from trade openness to carbon dioxide emission, and from nitrous oxide and methane leading trade openness. The key variables of interest, for instance trade openness was found to be statistically significant only for carbon dioxide emission, showing no significant effect on nitrous oxide and methane. Even though the long run estimates show that trade openness reduces emission of nitrous oxide and methane but not carbon dioxide. From the system GMM estimates, trade openness showed significant positive effect on carbon dioxide emission implying a harmful implication of trade on the environment, thus trade increases economic activities thereby increase carbon dioxide pollution. Although the inverted U-shaped EKC was not confirmed for all the four different models for the three dependent variables (CO_2, N_2O and CH_4), real income *per capita* was found to have significant negative effect on emissions. The study finds no evidence that trade openness played a significant role in the emission of nitrous oxide and methane for the two regions.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.0 Introduction

Recent trends of climate change and increase in emissions have resulted in concerns by all parties concerned as to the effect of trade liberalization on the environment. This study looked at this concerning relationship from the regions that have received least attention. This chapter presents the concluding remarks of the study and provides some policy prescriptions for consideration.

6.1 Conclusion

The primary objective of this study was to examine the role of trade on environmental quality for SSA and East Asia, using dataset for 54 countries for the period of 1985-2018. We also sought to assess the long-run relationship between emissions and trade openness and finally examine the direction of causality between trade openness and emissions.

The effect of trade openness on the environment cannot be underestimated especially in the regions that have received least attention on this topic. Review of the literature reports varying results on the role of trade on the environment. The empirical literature reviewed reports of almost non-existence of studies seeking to analyze the causal relationship between trade and the environment particularly between SSA and East Asia. This study therefore attempts to bridge the empirical gap by estimating the long-run relationship using a panel cointegration technique. This constitutes an original contribution to the literature on the trade-environment nexus.

The analysis is conducted over a sample of 54 selected countries consisting of 47 Sub-Saharan African countries and 7 East Asian countries. The panel estimation procedure is used to assess the causality and long-run relationship of the variables of interest. The Arellano-Bover/Blundell-Bond linear dynamic panel-data estimation technique is used mainly to correct for endogeneity stemming from trade and income and serial correlation problems associated with the dynamic panel. The study finds different results from the works of Copeland and Taylor (2001) and Cole and Elliot (2003) among others. For instance, while they found trade openness increases pollution of N_2O, we found that trade openness does not significantly impact N_2O emissions. Hence, differences in method, type of data and regions under study are crucially essential in determining the trade-induced effect on the environment.

The estimated results provide a number of conclusions. First the study establishes that the effect of trade openness on the environment of SSA and East Asian countries is inconsistent across the environmental quality variables rather it depends on a specific indicator that it studies. The results report that trade openness plays a positive significant role in the emission of carbon dioxide. The results indicate that a unit increase in trade openness increases CO_2 emissions and thereby causes environmental quality to fall. On the contrary, we find that trade does not play a significant role in the emission of N_2O and CH_4 and therefore its effect on the environment is negligible, albeit directional effects that conformed with theory.

Environmental regulation and institution was also found to have counterintuitive results on environmental quality, showing for all pollutants, evidence of increasing emission with high environmental regulations. The plausible explanation to this is that designing and implementation of higher environmental standards could not necessarily corroborate with enforcement, empowerment of regulating agencies, and human mind-set and attitude.

Lastly, the trade-emission (trade-environmental quality) nexus was found to be unidirectional. Converse causal relationships were found to exist between trade openness on one hand, and the three emissions on the other. Thus, while a unidirectional causal relationship running from trade to carbon dioxide emission was found, the unidirectional relationship between nitrous oxide and methane on one side, and trade openness on the other hand were found to run from the former to the later.

The general implication from the study is that trade effect on the environment is not the same for all pollutants, in both significance, magnitude and directional effects. This is further reiterated by the causality result for the various forms of emissions and trade openness. Even though the short run results indicated no significant relationship between trade openness and the emission (of nitrous oxide and methane), our long run estimates from the DOLS results depicted that trade openness actually can reduce nitrous oxide and methane emission in the long run.

6.2 Policy Recommendation

The study results indicated a trade-induced carbon dioxide emission, implying a positive effect of trade on carbon emission. However, the study would suggest that this development of increased emission, and for that matter, deterioration of the environment should not be blamed entirely on trade openness. The researcher is of the notion that trade in itself is not harmful, but the trade arrangements is what require redress within these two regions (SSA and East Asia). Hence, there is no need to limit the ongoing trade liberalization process within these regions and the rest of the world. Rather, the trade arrangements and the trade regulation should be strategically addressed. Especially, trade restrictions on carbon emitting produce must be firmly enforced. This will ensure that trade of second-hand cars, and other home appliances and automobiles that do not meet environmental standards are highly regulated and duly enforced especially damping of emitting goods particularly in the SSA sub-region. It is imperative also to support both regions economic growth and free and fair trade. This would require collaborative efforts of the World Trade Organization (WTO) and the Environmental Protection Agencies.

Also, trade showed reducing but insignificant effect on emission of methane and nitrous oxide. This promises trade-induced improvement in environmental quality for agriculture-related emissions. Following from this finding, the study makes the following recommendations:

- designing of strategic policies that supports and promotes trade of agriculture produce, as well as effectively regulate the possible environmental implications of these produce.
- the need for intensification of education on best farming practice, particularly, the need to adopt organic, environmental-friendly fertilizers where appropriate and also promote the efficient application of fertilizers to meet plant needs.
- for this to be effective, the study would recommend not only intensification of the existing collaborative effort between the agriculture and educational sectors through the expansive utilization of Agric-extension officers, but also, the decentralization of these efforts to the regional and district levels to ensure effective and efficient collaborative effort.

Interestingly, study results show negative effect of environmental regulation on nitrous oxide and methane emission. This finding was shown to be counterintuitive to theory and goes beyond practical comprehension. However, the engineering and function of policies goes beyond just implementation. There are related institutional arrangements like monitoring and evaluation, enforcement, institutional resourcefulness as well as individual attitudes that influence policy effectiveness. To derive the full benefit of environmental regulations; the study recommends the following:

- apart from policy implementation, there is the need to ensure enforcement. It is therefore recommended that environmental protection agencies across continents should ensure that environmental standards are duly enforced, with stringent penalties for defaulters.
- the regulatory bodies and enforcing institutions should also be adequately equipped with the requisite resource, both human and capital. This would ensure that they are well empowered to carried out effective and efficient enforcement of the regulations.
- individuals, corporations, and various stakeholders should have the right attitude and mindset towards environmental protection and sustainability. With all the physical resources and varying policies, there is ultimately the need for people to positively change their mindsets and attitudes towards the environment. Education can have the needed impact, but without the positive attitude and individual willingness to promote a quality environment.

In addition, there should be a programme or agreement between these two regions to develop a technical solution that will help reduce levels of pollution and environmental degradation generated by the manufacturing sector. Also, there is a need to develop an international taxation system as part of regulation to tax countries who emit GHGs beyond set standards.

It is generally recommended that these policies recommendations should at best, not be undertaken or implemented in isolation. Both economic and environmental policies when harnessed together could promote environmental sustainability by ensuring that the major externalities, if not all, are strategically internalized. This will ensure optimal gain from trade given effective environmental policies and proactive economic reforms.

6.3 Areas for Further Studies

This current study was limited to three pollutants, namely, carbon dioxide, nitrous oxide, and methane, and could not take into consideration the effect on other environmentally harmful pollutants like the Fluorinated gases as well as Biochemical Oxygen Demand (BOD); relating to water pollution and Sulphur dioxide. This however, does not bias the findings of this current study because one of the most common pollutants, carbon dioxide is considered. Future studies can look into the role these gases play in the trade environment nexus.

The study initially intended to cover the whole of SSA and East Asia. All 47 SSA countries were considered in the panel and 7 out of the 8 countries from East Asia. Taiwan was not included in the panel data, hence, in the study analysis due to insufficient information in the World Development Indicator (WDI) database on Taiwan. Although exclusion of Taiwan from the analysis should not reduce the generalizability power of this finding to the whole of SSA and East Asia, the researcher believes that this could possibly blur the study findings. Full data availability on these regions should promote a study to assess how the results would change if all countries are considered.

The findings on environmental regulations and emissions arouse interest for further empirical studies, especially with the African sub-regions. A study on the economic cost and environmental outcomes of environmental regulation and the firm-level emission and its effect on the environment could be an area for further study.

References

Acemoglu, D., Simon J., James A.R., & Pierre Y. (2008). Income and democracy. *American Economic Review, 98*(3): 808–42.

Afonso, A., & Furceri, D. (2008). Government size, composition, volatility and economic growth. *European Central Bank Working Paper No. 849*.

Aldrich, J. (2004). The discovery of comparative advantage. *Journal of the History of Economic Thought*, 26(3): 379-399.

Ambec, S., Cohen M.A., Elgie S., & Loine, P. (2011). The porter hypothesis at 20. Can environmental regulation enhance innovation and competitiveness? *Discussion Paper RFF DP* 11-01. Washington DC.

Anderson, T.W., & Hsiao, C. (1982). Formulation and estimation of dynamic models using panel

Antweiler, W., Copeland, B.R., & Taylor, M.S. (2001). Is Free Trade Good for the environment? *American Economic Review*, 9(4): 877-908.

Arbia, G., & Piras, G. (2005). Convergence in per-capita GDP across EU-NUTS2 regions using panel data models extended to spatial autocorrelation effects. *Discussion Paper*. Retrieved May 14, 2019, from www.real.illinois.edu/d-paper/05/05-t-3.pdf

Arellano, M., & Bover, O. (1995). Another look at the instrumental variable estimation of error components models. *Journal of Econometrics* Vol. 68, pp.29-51.

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies, 58*: 277-97.

Aslanidis, N. (2009). Environmental Kuznets Curves for Carbon Emissions: A Critical Survey. *Working Paper, No 51.*

Ayodotun, A., & Farayibi, A. (2016). An empirical analysis of the structure of imports in Sub-Sahara Africa. *MPRA Paper No. 73278.*

Babatunde, A., & Egwaikhide, F. (2010). Explaining Nigeria ‘s import demand behavior: a bound testing approach. *International Journal of Development Issues, 3*(7), 176-187.

Baek, J., Cho, Y., & Koo, W.W. (2009). The environmental consequences of globalization: A country-specific time-series analysis. *Ecological Economics*, *68*(8–9), 2255–2264.

Bamou, E., & Adeola, A. (2006). Impact of china and India on Sub-Sahara Africa. evaluating Asian drivers impacts on Sub-Saharan Africa oil and gas industries: a methodological framework. *Final Report submitted to AERC*, November, 2006.

Barro, R.J. (1991). Economic growth in a cross section of countries. *Quarterly Journal of Economics, 106*(2): 407-443

Beckerman, W. (1992). Economics growth and the environment: whose growth? Whose environment? *World Development, 20*, 481-496.

Bernard, J., & Mandal, S.K. (2016). The impact of trade openness on environmental quality: an empirical analysis of emerging and developing economies. *WIT Transactions on Ecology and the Environment, 203*: 195-208.

Bernauer, T., & Koubi, V. (2004). On the political determinants of environmental quality. *Paper presented at the annual meeting of the American Political Science Association, Hilton Chicago and the Palmer House Hilton, Chicago, IL.*

Bernauer, T., & Koubi, V. (2006). Effects of political institutions on air quality. *Ecological Economics, 68*(5), 1355-1365.

Blundell, R. & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data

Bond, S., Hoeffler, A., & Temple, J. (2001). GMM estimation of empirical growth models. *Economics Papers*, 1-35.

Breitung, J. (2000). The local power of some unit root tests for panel data. In Advances in Econometrics, Volume15: Nonstationary Panels, Panel Cointegration, and Dynamic Panels, ed.B. H. Baltagi, 161–178. Amsterdam: JAIPress.

Breitung, J., & Das S. (2005). Panel unit root tests under cross-sectional dependence. *StatisticaNeerlandica* 59:414–433.

Busse, M. (2004). Trade, environmental regulations and the World Trade Organization: new empirical evidence. *Hamburg Institute of International Economics (HWWA) Department World Economy Neuer Jungfernstieg*, 21 D-20347 Hamburg, Germany.

Chakraborty, D., & Mukherjee, S. (2013). How do trade and investment flows affect environmental sustainability? Evidence from panel data. *Environmental Development*, *6*: 34–47.

Chang, N. (2012). The empirical relationship between openness and environmental pollution in China. *Journal of Environmental Planning and Management*, *55*(6): 783–796.

Choi, I. (2001). Unit root tests for panel data. *Journal of International Money and Finance* 20: 249–272.

Cisse, D. (2012). FOCAC: Trade investments and aid in China-Africa relations. Available at http://scholar.sun.ac.za/ handle/10019.1/21429

Cole, M.A. (2003). Trade, the pollution haven hypothesis and the environmental Kuznets curve: examining the linkages. *Ecological Economics*, 71-81.

Cole, M.A., & Elliot, R.J.R. (2003a). Do environmental regulations influence trade patterns? Testing old and new trade theories. *The World Economy*, *26*(8):1163-1186.

Cole, M.A., & Elliott, R.J.R. (2003b). Determining the trade–environment composition effect: the role of capital, labour and environmental regulations. *Journal of Environmental Economics and Management*, *46*(3): 363-383.

Cole, M.A., & Elliott, R.J.R. (2005). FDI and the Capital Intensity of 'Dirty' Sectors: A Missing Piece of the Pollution Haven Puzzle. *Review of Development Economics, 9*(4), 530-548.

Copeland, B., & Taylor, M.S. (2004). Trade, growth, and the environment. *Journal of Economic Literature, 42*(1): 7-71.

de Alwis, J.M.D.D.J. (2015). Environmental Consequence of Trade Openness for Environmental Goods. *Sri Lankan Journal of Agricultural Economics*, Vol. 16, No. 1.

Deardorff, A. (2011). *Comparative Advantage: Theory behind Measurement.* OECD Publishing.

Doudu, A. (2018). Is trade bad for the environment? Decomposing the impact of trade on environmental quality. A Master of Economics thesis submitted to the School of Economics and Management, Lund University, June, 2018.

Dumitrescu, E.-I., & Hurlin, C. (2012). Testing for Granger non-causality in heterogeneous panels, 29(4):1450 (1460).

Eunho Choi, A. H. (2010). An Empirical Study of the Relationships between CO2 Emissions, Economic Growth and Openness. *IZA.*

EPA. (2017, April). *Total U.S. Greenhouse Gas Emissions by Economic Sector in 2015*. Retrieved June 29, 2017, from United State Environmental Protection Agency.

Eskeland, G., & Harrison, A. (2002). Moving to Greener Pastures? Multinationals and the Pollution Haven Hypothesis. *NBER Working Paper No. 8888, April.*

Evita, S. (2016). Africa's position in global trade. free trade agreements, wto and regional integration. *Unpublished manuscript retrieved from:* *https://www.swp-berlin.org/fileadmin/contents/products/projekt_papiere/Africas_Position_in_Global_Trade.pdf*

FAOSTAT. (2011). http://faostat.fao.org.

Forster, P., Ramaswamy, V., Artaxo, P., Berntsen, T.R.B., Fahey, D.W., & Van Dorland, R. (2007). Changes in atmospheric constituents and in radiative forcing. *In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* (S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, . . . H. L. Miller, Eds.) United Kingdom and New York, USA: Cambridge University Press.

Frankel, J. & Rose, A. (2005). Is trade good or bad for the environment? sorting out the causality. *Review of Economics and Statistics*, *87*(1): 85-91.

Frankel, J. (2009). Environmental effects of international trade. *Harvard Kennedy School Faculty Research Working Paper*, RWP09-006.

Fredriksson, P.G., List, J.A., & Millimet, D.L. (2003). Corruption, environmental policy, and FDI: theory and evidence from the United States. *Journal of Public Economics*, 87, pp. 1407–1430.

Gavrilescu, M. (2004). Cleaner production as a tool for sustainable development. *Environmental engineering and management journal*. 3, pp.45-70.

Gozgor, G. & Can, M. (2017). Does export product quality matter for CO 2 emissions? Evidence from China. *Environmental Science and Pollution Research*, *24*(3): 2866-2875.

Granger, C.W.J., (1969). Investigating causal relations by econometric models and cross spectral.

Grether, J., Mathys, N.A., & De Melo, J. (2006). Unveiling the world-wide pollution haven effect. *Fondazie Eni Enrico Mattei.* Nota di lavoro.

Grossman, G.M., & Krueger, A.B. (1991). Environmental impacts of a North American free trade agreement. *National Bureau of Economic Research.* (No. w3914).

Grossman, G.M., & Krueger, A.B. (1993). *Environmental impacts of the north free trade agreement, the us-mexico free trade agreement*. Cambridge, MA: MIT Press.

Grossman, G.M., & Krueger, A.B. (1995). Economic growth and the environment. *Quarterly Journal of Economics*, *110*(2): 353-377.

Gujarati, D. (2014). Econometrics by example. *Palgrave Macmillan*.

Hadri, K. (2000). Testing for stationarity in heterogeneous panel data. *Econometrics Journa*l, 3:148–161.

Halkos, G. (2012). The impact of government expenditure on the environment: An empirical investigation. *Ecological Economics*, *91*: 48-56

Halkos, G., & Polemis M. (2017). Does financial development affect environmental degradation? Evidence from the OECD countries. *Business Strategy and the Environment*, 26(8): 1162–1180.

Hanley, N., Shrogen, F., & White, B. (2001). *An introduction to environmental economics*. Oxford University Press. London, UK.

Harris, R. D. F., & Tzavalis E. (1999). Inference for unit roots in dynamic panels where the time dimension is fixed. *Journal of Econometrics* 91: 201–226.

Harrison, A. (1995). Openness and Growth: A Time-Series, Cross-Country Analysis for Developing Countries. *NBER Working Paper* No. 5221, August.

Harvey, A., & Sedegah, D. (2011). Import demand in Ghana: Structure, behaviour and stability. *AERC Paper Nairobi*, 233, 1-27

Helpman, E. (1988). Growth, Technological Progress, and Trade. *National Bureau of Economic Research Reprint no. 1145*.heterogeneous panels. *Journal of the American Statistical Association*, Vol.94(446), pp.621-634.

https://unctad.org/en/pages/PublicationWebflyer.aspx?publicationid=1662

IBRD (1992). *World Development Report 1992. Development and the Environment.* New York: Oxford University Press.

Ibrahim, M. H., & Law, S. H. (2016). Institutional quality and CO2 emission- trade relations: Evidence from Sub-saharan Africa. *South African Journal of Economics, 84*(2), 323-340.

Im, K.S., Pesaran M.H., & Shin Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics* 115: 53–74.

IPCC (2014). Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Jafari, Y., Farhadi, M., & Zimmermann, A. (2017). Economic liberalization and the environmental Kuznets curve: some empirical evidence. *Journal of Economic* Development, 42(1): 1-34

Jeffrey, A.F., & Andrew, K.R. (2002). Is trade good or bad for the environment? sorting out the causality. *NBER Working Papers*, 9201.

Jenkins, R., & Edwards C. (2006). The economic impacts of china and India on Sub-Saharan Africa. *Journal of Asian Economics,* 17: 207–225.

Kankesu J., Reetu V., & Ying L. (2001). Co2 emissions, energy consumption, trade and income: A comparative analysis of China and India. *Energy Policy42*, 2012: 450–460.

Kao, C., & Chiang, M.H (2000). On the estimation and inference of a cointegrated regression in panel data. Advances in Econometrics, 15, 179-222.

Kijima, M., Nishide, K., & Ohyama, A. (2010). Economic models for the environmental Kuznets curve: A survey. *Journal of Economic Dynamics and Control, 34*(7): 1187–1201.

Korves, N., Martínez-Zarzoso, I., & Voicu, A.M. (2011). Is free trade good or bad for the environment? New empirical evidence. *Climate Change –Socioeconomic Effects Blanco and Kheradmand*:1–30. Rijeka, Croatia.

Krueger, A. (1997). Trade policy and economic development: How we learn. *American Economic Review, 87*(1): 1-22.

Kukla-Gryz, A. (2009). Economic growth, international trade and air pollution: A decomposition analysis. *Ecological Economics,* 68(5): 1329-1339.

Kuznets, S. (1955). Economic growth and income inequality. *American Economic Review, 45*: 1–28.

Levin, A., Lin C.-F & Chu C.-S. J. (2002). Unit root tests in panel data: Asymptotic and finite-sample properties. *Journal of Econometrics* 108: 1–24.

Lin, B., Omoju, O.E., Nwakeze, N.M., Okonkwo, J.U., & Megbowon, E. T. (2016). Is the environmental Kuznets curve hypothesis a sound basis for environmental policy in Africa? *Journal of Cleaner Production, 133,* 712-724.

Lomborg, B. (2001). *The skeptical environmentalist: Measuring the real state of the world.* Cambridge: Cambridge University Press.

Managi, S., Hibiki, A., & Tsurumi, T. (2009). Does trade openness improve environmental quality? *Journal of environmental economics and management*, 58(3): 346-363.

McCartney, G., & Adamowicz, V. (2005). The Effects of Trade Liberalization on the Environment: An Empirical Study, selected paper prepared for presentation at the Canadian Agricultural Economics Society Annual Meeting 6-8 July, San Francisco, California.

Meadows, D.H., Meadows, D.L., Randers, J., & Behrens, W. (1972). *The Limits to Growth.* New York: Universe Books. methods, *Econometrica* 37(3); 424-438.

Morrison, A. (2009). Democracy and the environment: The visibility factor. Paper presented at the Annual Meeting of the Midwest Political Science Association 67th Annual National Conference, The Palmer House Hilton, Chicago, I.L.

Nickell, S.J. (1981). Biases in dynamic models with fixed effects. *Econometrica,* 49.

Ohlin, H. (1933) *Interregional and International Trade*. Harvard University Press. Harvard, USA.

Omri, A., Daly, S., Rault, C., & Chaibi, A. (2015). Financial development, environmental quality, trade and economic growth: What causes what in MENA countries. *Energy Economics,*

Panayotou, T. (1997). Demystifying the environmental Kuznets curve: turning a black box into a policy tool. *Environment and development economics*, *2*(4): 465-484.

Pesaran, M.H., Shin, Y., & Smith, R. (1999). Pooled Mean Group Estimation of Dynamic Heterogeneous Panels. *Journal of the American Statistical Association*, *94*(446), 621-34.

Porter, M. (1991), America's Green Strategy. *Scientific American, 264*(4): 168.

Porter, M., & van der Linde, C. (1995). Toward a new conception of the environment competitiveness relationship. *Journal of Economic Perspective*, *9*(4): 97–118.

Roodman, D. (2009). How to do Xtabond2: An Introduction to Difference and System GMM in Stata. *Stata Journal*, 9(1), 86-136.

Samuelson, P.A. (1973). *Economics*. H.C Graw Hill, Kogakusha Ltd.

Selden, T.M., & Song, D. (1994). Environmental Quality and Development: Is There a Kuznets Curve for Air Pollution Emissions? *Journal of Environmental Economics and Management*, *27*:1 47-162

Shafik, N. (1994). Economic Development and Environmental Quality: An Econometric Analysis. *Oxford Economic Papers*, 46: 757-773.

Shafik, N., & Bandyopadhyay, S. (1992). Economic growth and environmental quality: time-series and cross-country evidence. *World Bank Publications, 904.*

Shahbaz, M., Hye, Q.M.A., Tiwari, A.K., & Leitao, N.C. (2013). Economic growth, energy consumption, financial development, international trade and CO2 emissions in Indonesia. *Renewable and Sustainable Energy Reviews*, 25: 109–121

Sharma, S.S. (2011). Determinants of carbon dioxide emissions: empirical evidence from 69 countries. *Applied Energy*, *88*(1): 376–382.

Somerville, R., Le Treut, H., Cubasch, U., & Ding, Y., Mauritzen, C., Mokssit, A., & Prather, M. (2007). *Historical Overview of Climate Change. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* (S. Solomon, D. Qin, M. Manning, Z. Chen, M. M, K. B. Averyt, & H. L. Miller, Eds.) United Kingdom and New York, USA: Cambridge University Press.

Stern, N. (2006). The Economics of Climate Change*: The Stern Review*, Cambridge University Press, Cambridge: 308-320.

Stock, J.H. & Watson, M., (1993). A simple estimator of cointegrating vectors in higher order integrating systems. *Econometrica*, *61*: 783-820.

Stoessel, M. (2001). Trade liberalization and climate change. The Graduate Institute of International Studies, Geneva.

Stolper, W., & Samuelson, P. (1941) *Protection and Real Wages.* Review of Economic Studies. Cambridge University Press. London.

Tamazian, A., & Rao, B.B. (2010). Do economic, financial and institutional developments matter for environmental degradation? Evidence from transitional economies. *Energy Economics*, 32(1): 137–145.

Tobey, J. (1990). The effects of domestic environmental policies on patterns of world trade: an empirical test. *Kyklos, 43*: 191–209.

Tobey, J.A. (1990). The effects of domestic environmental policies on patterns of world trade: an empirical test. Kyklos.

Tsurumi, T., & Managi, S. (2010). Decomposition of the environmental Kuznets curve: scale, technique, and composition effects. *Environmental Economics and Policy Studies, 11*(4): 19-36.

Vogel, D. (1995). *Trading Up: Consumer and Environmental Regulation in a Global Economy*. Harvard University Press.

Twerefou, D.K., Akpalu, W. & Mensah, A. C. E. (2019). Trade-induced environmental quality: the role of factor endowment and environmental regulation in Africa. *Climate and Development*, DOI: 10.1080/17565529.2018.1562868

Vijayasri, G. V. (2013). The importance of international trade in the world. *International Journal of Marketing, Financial Services & Management Research*, *2*(9), 111–119.

Wagner, M., & Grabarczyk, P. (2016). The Environmental Kuznets Curve for Carbon Dioxide Emissions: A Seemingly Unrelated Cointegrating Polynomial Regressions Approach. *Universitätsbibliothek Dortmund.*

World Bank (2013). World Development Indicators, World Bank, Washington, DC accessed from http://databank.worldbank.org/data/views/variableSelection/selectvariables.aspx?source=worlddevelopment-indicators

World Bank. (1992). *World Development Report 1992.* New York: Oxford University Press.

World Trade Organization (2009). Trade and climate change. *WTO-UNEP report*. Accessed October 17, 2018 from https://www.wto.org/english/res_e/booksp_e/trade_climate_change_e.pdf

Yandle, B., Vijayaraghavan, M., & Bhattarai, M. (2002). The Environmental Kuznets Curve: A Primer. *PERC Research Study, 02*-1.

Appendix A

List of Countries

Sub-Saharan Countries	East Asia
Angola	China
Benin	Hong Kong SAR, China
Botswana	Macao SAR, China
Burundi	Japan
Burkina Faso	Mongolia
Cameroon	Korea, Dem. People's Republic.
Cote d'Ivoire	Korea, Republic.
Cabo Verde	
Central African Republic	
Chad	
Comoros	
Congo, Dem. Rep.	
Congo, Rep.	
Djibouti	
Equatorial Guinea	
Eritrea	
Ethiopia	
Gabon	
Gambia, The	
Ghana	
Guinea	
Guinea-Bissau	
Kenya	
Lesotho	
Liberia	
Malawi	
Madagascar	
Mali	
Mauritania	
Mauritius	
Namibia	
Niger	
Nigeria	
Rwanda	
Sao Tome and Principe	
Senegal	
Seychelles	
Sierra Leone	
Somalia	
South Africa	
South Sudan	
Sudan	
Tanzania	
Togo	
Uganda	
Zambia	
Zimbabwe	