ENVIRONMENTAL EFFICIENCY AND NIGERIA'S BILATERAL TRADE

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B. Sc. (Econ); M. Sc. (Econ) (Ibadan)

Matric No. 133903

A Thesis in the Department of Economics

Submitted to the School of Economics

In Partial Fulfilment of the Requirements for the Award of the Degree of

DOCTOR OF PHILOSOPHY

of the

UNIVERSITY OF IBADAN

March, 2021

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DEDICATION

This thesis is dedicated to the Almighty God, the owner of life, who in his infinite mercy and grace has helped me through my studies. He has been my father indeed, ever faithful and dependable.

I also dedicate this work to my mother of blessed memory, late Mrs Rachael Awodumi, who laboured all her life solely for her children but could not wait for the rewards. You are always remembered.

ACKNOWLEDGEMENT

I want to give all the glory to the Almighty God, the Al-sufficient and Giver of life. He alone is worthy of my praise for His infinite mercy, steadfast love and abundant grace that endure forever. He manifested Himself at every point of this programme and for His sake I am living to see the completion of this dissertation.

I must say that I am most favoured of all men for orchestrating my steps to a rich and beautiful land flowing with 'academic milk and honey'. I do not just have a supervisor in Professor Adeolu Olusegun Adewuyi, I have a principled mentor, seasoned teacher, compassionate father, trusted confidant and humble friend. He listens and shares the plight of his students. His approach to supervision is worthy of emulation. Prof, I sincerely thank you for your simplicity and fatherly approach in correcting, adjusting and commending my efforts in this dissertation. You are highly appreciated. God bless you sir.

Special appreciation goes to my thesis committee members, Dr. Oluwatosin Adeniyi and Dr. Solomon Abayomi Olakojo who are rare gift during my postgraduate programme (M.Sc. and Ph.D.). Despite their very busy schedules, they have always created ample time for discussions on this thesis, while their comments and suggestions have enhanced the quality of the dissertation. God bless you sirs.

I am highly indebted to my lecturers and fathers in the Department of Economics, University of Ibadan, who have taught me Economics (both in theory and practice) and are instrumental to the high-quality thesis I produced which I am boastful of. I appreciate the Head, Department of Economics, Prof. Olawale Ogunkola for his open arms when we (his students) call and his useful comments on the proposal and draft report. I specially appreciate the Postgraduate Programme Director, Dr.Mutiu Oyinlola and the Sub-Dean Postgraduate Programme, Prof. Omo Aregbeyen for their much-needed comments on my post-field report and efforts in giving my abstract a 'sweet taste'. I am equally indebted to Prof. Emeritus Oyejide, Prof. Egwaikhide, Prof. Olaniyan, Prof.

Bankole, Prof. Ogun, Prof. Ogwumike, Prof. Folawewo and Dr.Oyeranti whose comments and suggestions have contributed greatly to the quality of this thesis. I also appreciate Drs. Aminu, Lawanson, Babatunde, Fowowe, Orekoya, Foye, Ajayi, Ojebode and Atanda for their contribution to my thesis and abstract. I must not forget my 'in-law', Dr. Noah Olasehinde, who is always a big source of encouragement, especially at those difficult situations during this programme. How can I forget that push for my international exposure?

I also thank the African Economic Research Consortium (AERC), who provided the funds to carry out this research. I am also grateful to Africalics and Globelics for providing the platforms to disseminate the output of this dissertation to seasoned audience and experts around the globe. My experience at the Lindau Meeting of the Nobel Laureates in Germany provided extra motivation for my career in research.

To the love of my life, my Soulmate, my Treasure and sweetheart, Adebisi Elizabeth ArikeAwodumi (Nee Olawuyi), my gratitude is forever. I know I have exhibited several unacceptable characters and have been nasty at different times during this programme. I have yelled, transferred aggressions, travelled, kept vigils against your (medical) advice and not fulfilled some promises. Yet, you remained patient with me and still believed in me without any reservation. You have supported and encouraged me through thick and thin. Your care, prayers and love were indeed my motivation during this programme. You will always be my TREASURE and I will forever love, cherish and appreciate you.

To my lovely baby, Hephzibah Adeewa Princess Abike Awodumi, your arrival is indeed a great blessing to the family. Thank you for your cooperation with Daddy and Mummy during those nights and travels. My thanks and gratitude go my late mother, Mrs Rachael Awodumi, the best mother I have ever known, for showing us the way before her departure. Also, to my Dad, Mr Simeon AdemakinAwodumi and my siblings, Bunmi, Olagoke and Adeola, you are a rare gift to my life. Thank you for all your support and prayers. The good Lord will bless you with all the desires of your hearth in Jesus Name.I must also say a big thank you to the Olawuyis, Dad, Mum, Samuel, Dorcas and Daniel, who graciously allowed me to be part of their family, and have never stopped supporting me in all circumstances. Thanks a million and keep reigning.

My appreciation knows no bounds to Prof, and Mrs. D. D. O. Oyebola (and family), Mr. John Okuwobi and Pastor and Mrs. Afuye. You are a blessing to me and my family al-through. To the entire Chapel of Miracle family, God bless you all for providing the atmosphere for quality worship of our Father. I am especially grateful to Pastor and Pastor (Mrs) Adegbola Adedipe, Pastor and Deaconess Sadiku, Pastor and Deaconess Aliu and Pastor and Deaconess Owolabi. I also appreciate Bro and Mrs Odunaro and Bro and Mrs Emoikpeire. Thank you and God bless you more abundantly.

I also want to show my gratitude to my friends and colleagues. This includes Dr Sunday Adegbite (and family), OyetejuOdufuwa (and family), Musefiu Adeleke, Oyeleke Famade (Association of Graduate Economics Students-AGES President), Dr Damilola Arawomo, Lekan Oshota, Segun Adeboye, Joseph Ogebe, Tope Abodunde, Dr Bashiru Fatai, Oluwole Oletubo, Fatai Adedeji, Oludele Folarin, Festus Osagu, Dr Francis Adeyemi, Dr BusuyiFalayi, SekinatOpeloyeru, Adesina Raifu, Nigerian Institute of Social and Economic Research-NISER class of 2018 and the Economic and Business Policy Department of the Institute. I also thank all the non-academic staff of the Department of Economics, University of Ibadan, especially Mrs Farotimi, Mrs Akinrinola, Mrs Oladele and Mrs Edalere for their support. To all those who have one way or the other contributed to the success of my Ph.D. programme in the University of Ibadan, I love you all.

Finally, I appreciate my humble self, Olabanji Benjamin Awodumi, for your self-motivation and encouragement when it seemed all was over. Thank you and continue to enjoy more of God’s Grace.

ABSTRACT

Despite the rise in Nigeria's Bilateral Trade (BT) relations with her major trading partners, non-mineral exports remained below 5% of total exports during the 1996-2015 period. This reflects the fact that many countries adopt environmental standards as technical barriers to trade in response to high pollution intensive imports. While the country's average real output increased by over 200%, carbon emission also rose by almost 150%, raising serious concern for Environmental Efficiency (EE). The implication of EE for trade has not been given adequate scholarly attention, as most studies only measured the level of EE (outcome variable), and a few others focused on the role of environmental regulation (policy variable). This study, therefore, investigated the implication of EE in Nigeria's BT with 10 European Union (EU) and seven Asian countries, at aggregate and sectoral levelsduring the period.

The Heckscher-Ohlin Trade Theory provided the framework for this study. An extended Gravity Econometric Model that captured the effect of EE on BT was explored. The EE indicator was computed using Data Envelopment Analysis (DEA). Aggregate (all products) and sectoral models were estimated using the generalised least squares and negative binomial pseudo-maximum likelihood estimators, respectively. Diagnostic tests (Wald and Bayesian information criteria) were used to determinethe robustness of the estimates. Data were sourced from the World Development Indicators and World Integrated Trade Solutions. Regression estimates were validated at $\alpha \leq 0.05$.

The implication of EE for BT is found to vary by product level (aggregate and sectoral) and by partner (EU or Asia). For aggregate models, a 1.0% improvement in EE in Nigeria raised imports from, and exports to, the EU by 1.5% and 2.9%, respectively. However, it improved only imports from Asia by 1.7%.An improvement in sources' EE increased Nigeria's imports from Asia, but only negligibly from the EU. At the sectoral level,an increase of 1.0% in Nigeria's EE promoted mineral imports (by 0.8%) and exports (by 0.6%) to the EU, while the effect on trade with Asia was insignificant. A 1.0% increase in EU's EE raised mineral imports from Nigeria by 3.3%. On the other hand, a similar increase in EE in Asia raised Nigeria's mineral imports from the region by 1.8%.For non-mineral products, EE in Nigeria and in her partners' economies yielded insignificant effect on BT. Further analysis of these products (agriculture and manufacturing) shows insignificant effect of EE on trade in agricultural products between Nigeria and the EU; but increased Nigeria's imports from Asia by 0.7% in response to 1.0% improvement in EE on both sides. Moreover, the EE in Nigeria promoted manufactured exports to Asia by 0.8%, while in the EU and Asia, it produced negligible effect.

Improvement in environmental efficiencysubstantially stimulates aggregate bilateral trade between Nigeria and her partners in the EU and Asia, though the effects are mixed at sectoral levels. Therefore, Nigeria must focus on the design of pollution tax and incentives that encourage firms to adopt innovation that curb environmental pollution so as to enhance competitiveness.

Keywords: Environmental efficiency, Bilateral trade, Heckscher-Ohlin Model, Nigeria's trade partners

Word count: 495

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CHAPTER ONE

INTRODUCTION

1.1 Preamble

Many nations of the world have witnessed increased economic growth over the past three to four decades which has equally contributed to their improved participation in world trade. However, in the process of production of output, hazardous pollutants are released to the environment which poses enormous threats to the health of plants, animals and man (Chen, Song and Xu, 2014 and Adewuyi and Awodumi, 2017). Concerns have been raised by stakeholders as production for exports, as well as consumption of imports, has increased the level of greenhouse gas that causes global warming, which became more pronounced with the growth of global trade. This led many countries to design environmental policies and regulations as well as set targets to drastically reduce environmental pollution, the success of which is reflected in the level of environmental efficiency of production processes across sectors.Environmental efficiency is a measure of the level of environmental pollution generated per unit of output (WBCSD, 2000 and Cicea, Marinescu, Popa and Dobrin, 2014).This development was recognized by the World Trade Organization (WTO) who warns against turning environment policies and regulations into technical barrier that serves as impediments to trade (WTO, 2014b and 2014c)[1].

In the theoretical literature, environmental efficiency has direct implication for costs of production which in turn influences trade decision of firms. Improvement in environmental efficiency raises export but its effect on import depends on the dominance of substitution or income effect. This is in line with the mixed evidences in the literature on the effect of

[1] The political dimensions in addressing environmental and sustainability issues in Nigeria and globally is acknowledge. However, due to the diverse national and stakeholders' interests during negotiations and policy designs, the political dimension is beyond the scope of this study.

environmental regulation on firms' competitiveness (Mulatu, Floraxand Withagen, 2004). In resource-rich developing countries where comparative advantage is already achieved in goods produced using the abundant resources intensively, environmental efficiency can either improve or hinder the existing comparative advantage position. For instance,government policies which enable firms to adopt environmentally efficient production techniques could generate costs to firms that outweigh the resulting benefits which consequently retard productivity and export especially in the short-run.The initial high cost of compliance with environmental regulation becomes a sunk cost, such that in the medium-to-long-run, there is reduction in cost per unit of output. Thus, adopting environmentally efficient production techniques increase output and produce lower emission resulting in greater benefits than costs to firms. In the process, the country's comparative advantage is further enhanced with positive influence on export (Doganay, Sayek and Taskın, 2014).

In Nigeria, real gross domestic product, which stood at about $60.72 billion in 1996, grew by over 200% over the period 1996-2014,reaching a record high of $194.88 billion in 2014. This remarkable growth performance, which is especially pronounced since the early 2000s, has some associated costs chief among which is environmental pollution. The level of carbon emission in the country averaged about 51thousand kilotons between 1996 and 1999 but jumped to an average of about 90 thousand kilotons during 2000-2014. The World Bank predicted that sustaining the pace of growth in Nigeria as contained in vision 20:2020 over a longer term suggestsby the end of 2035, greenhouse gas emission is expected to double as cumulative emissions over the period 2010-2035 may sum up to 11.6 million (five times the estimated historical emissionsbetween 1900 and 2005) tons of CO_2 to the atmosphere (World Bank, 2013).

Interestingly, Nigeria's total trade grew dramatically over the last three to four decades, where crude oil constantly contributed over 90% to total export for most part of this period. Similarly, non-mineral, especially consumer and industrial goods, contributed over 90% to total imports of the country for most part of the same period. Besides, Nigeria enjoys high trade relations withthe European Union (EU) who are highly committed to pollution reduction, as consumers are key stakeholders in driving clean goods and high quality environment. In fact, combined export of Nigeria to the top ten destinations in Europe reached about 40% of Nigeria's total export in 2013 and 2014, although imports dropped to about 23% in these years from about 50% in 1996.In contrast, trade relation with Asia, particularly China, has increased in recent years despite the rising level of environmental pollution in the region which may be traced to the wave of industrialisation, rather than consumers. In particular, import from the top seven Nigeria's trade partners in Asia reached about 35% in 2014. Thus, the dominance of the EU and Asia in Nigeria's bilateral trade relations, given the varying commitment to environmental quality, informs the choice of these regions. Therefore, understanding the dynamic link between trade and environmental quality is important as Nigeria seeks to improve its trade relations with her partners.

1.2 **Statement of the Problem**

The recent increase in the level of environmental pollution and global warming has raised serious concerns at every level of discussion and decision making around the world[2]. In Nigeria, real output increased from about $60.72 billion in 1996 to about $195 billion in 2014, representing over 200% growth while environmental pollution is higher than what obtains about two to three decades ago, with carbon emission rising by almost 150% over 1996-2013 (rising from 39,000kt in 1996 to 96000kt in 2013) (World Bank, 2017). Environmental pollution in Nigeria is characterised by very high composition of primary emissions (carbon monoxide, carbon dioxide, methane, chlorofluorocarbons and odours from garbage sewage, and industrial effluents) which contribute to greenhouse gas. Total greenhouse gas emission in the country rose by 129% between 1990-2005, and by 84% between 1990 and 2013(World Bank, 2017). This emission is observed to increase gradually in manufacturing industries and construction, as well as electricity and heat production, while the transport sector remained the leading source of emission for most part of the last two decades with gas flaring being dominant.

The problems caused by this development are apparent in Nigeria. According to the WHO (2015), if this trend continues with little or no investments in adaptation process, rise in

[2]According to World Bank, WDI (online), world carbon emission rose from about 24 million kt in 1996 to about 36 million kt in 2014.

sea level is projected to increase the menace of flooding which would affect over 500,000 people, on average annually, between 2070 and 2100. Moreover, deaths as a result ofclimate change is anticipated to rise to about 14.2% of total death due to child respiratory illnesses, high risk of premature deaths, cancer and asthma by 2050. The impact of air pollution which has adverse influence on health possessesnegative economic impacts, increasing medical costs while reducing productivitythrough loss in working days (EEA, 2015). Failure to take drastic action against this trend has serious implication for the health of the population, especially labour force, as well as cost of production, with the attending effect on local and international competitiveness.

This increased level of environmental pollution is also pronounced across most Nigeria's trading partners, especially in Asia. For instance, in Asia alone, carbon emission grew by over 85% between 1996 and 2014 (rising from 7.2 million kt in 1996 to 13.4 million kt in 2014),with China, large emitter of methane and black carbon,surpassing the United States in carbon dioxide emissionvolume in 2007 (IEA, 2009).It was equally estimated that about 44% of over 34,000 Chinese child deaths are associated with acute lower respiratory infections arising from air pollution which originates fromhouseholds (WHO, 2012).This is also evident across South West Asia where documented implications include respiratory diseases, lung cancer, labor loss, and economic burden in the long-run (Taghizadeh-Hesary and Taghizadeh-Hesary, 2020). Although, the European Union has been able to reduce carbon emission drastically in recent years, air pollution still remains the single largest environmental health risk factor in Europe where estimates from recent analysis indicate that the disease burden linked with air pollution is enormous (WHO, 2014, Doherty et al, 2017).

In spite of the growing environmental concerns, Nigeria's trade relation with Asia, as well as the EU has increased remarkably in recent years, with large volume of oil export and non-oil import. However, two striking problems continue to feature intrade policy debates in Nigeria with solutions constantly eluding the country – low level of non-mineral export and high influx of substandard and pollution intensive consumer and industrial goods.

Nigeria's export to major trading partners of the world has grown significantly in the past two decades, with crude oil constantly making up over 90% of total export, despite the relatively high environmental pollution in recent years (compare to about two decades ago)emanating from its production processes. However, manufacturing exports (as well as total non-mineral export) remained below 5% of total merchandise exports for most part of the same period. This low non-mineral export has been associated with a number of factors some of which are related to environmental issues. First, inadequate and decaying infrastructure has remained a major challenge to production and distribution activities in the country (NEPC, 2014). Specifically, the country has been plagued with irregular supply of electricity and the survival of firms depends on their ability to shift to private alternative energy supply which increases cost of production and reduce productivity in the process. Besides, since the private alternative energy supply largely comes from generating plants which use carbon-intensive energy, carbon emission is also released into the environment with itsnegative effect onthe health of man, as well as productivity.

A second and related problem is the lowquality of products that often fail to meet international standards, including those associated with production environment. For instance, importation of dried beans from Nigeria was banned bythe EU in June 2015 owing to the high level of pesticide which was considered injurious to human health.Since the Unionappears to be a top destination for Nigeria's non-mineral products with partners in the region importing a combined $52.79 million real worth of these products in 2012, a ban on Nigerian products is a major setback to production and export of the non-mineral sector[3].

Third, Nigeria is a major emitter of carbon emission from gas flaring, emitting over 30% of associated gas produced for most part of the period 1999-2014 (NNPC, 2015).Despite a remarkable reduction in gas flaring by over 60% between 199 and 2014, Nigeria flared 330,933 MMSCF of gas in 2015, losing about $850 million to gas flaring in the same year (DPR, 2015 and NNPC, 2015)[4]. Similarly, carbon emission from transport activities, which is a major user of fossil fuel, remains above 40% for most part of the last two or three decades (World Bank WDI, online). The resulting greenhouse gas (GHG) emissionis a major contributor to global warming, which leads to climate change that increases production costs, as reflected in poor health status of workers, poor working environment

[3]AgroNigeria (2016) and The Senate, Federal Republic of Nigeria (2016).
[4]MMSCF means million standard cubic feet.

and high pollution tax (as a result of high negative externality) to firms, both in the oil and non-oil sectors (UNDP, 2016 and Costa et al, 2016). Consequently, labour productivity falls and international market competitiveness declines, most especially in the non-mineral sector, which is labour-intensive rather than the capital-intensive mineral sector.Environmental degradation also contributes to the low Sanitary and Phytosanitary status of the non-mineral products in Nigeria, which is a major consideration for competitiveness of agricultural and manufactured goods in the international market (Bankole, 2003a and Bankole, 2003b).

Apart from food safety and phytosanitary in the importing countries, other factors that have been identified by stakeholders as mitigating the non-mineral export sector include financing constraints, low productive capacity, reliability and contract fidelity, poor and costly transport system,and underdeveloped regional and sub-regional markets (Awolowo, 2018).

Nigeria's import from pollution-intensive economies continues on the upward trend over the past two decades which threatens efforts towards sustainable development in the economy. For instance, imports from Asia alone grew by over 500% between 1996 and 2014, despite the high and increasing environmental pollution in the region.Such imports are largely composed of non-mineral products such as machinery and electronics (including computers, generators and phones), household appliances, automobiles, plastic and rubber, base metals, food items (live animals and vegetable products, beverages, cereals), drugs,clothing and textile materials, building materials, tyre and tubes and spare parts (NBS, 2015).

The flooding of Nigerian market with imported substandard products posesgreat challenge to stakeholders including the government,regulatory institutions, consumers and the entire public (Adewuyi and Arawomo, 2013 andOkorie and Humphrey, 2016). In Nigeria, Hussein and Kachwamba(2011) reported 84 death cases of children resulting from teething paindrugs that are harmful and melamine milk scandal as well as failure of home appliances.Also,Consumer Protection Council (2012) pointed out that about 1 million people lose their lives annually as a result of consumption of items that are substandard such as electrical parts, drinks, automobile, food and building materials.It was equally reported that the country losesmore than 1 trillion naira every yearfollowing and local production ofsubstandard items. These loses are reflected in local manufacturers income,expected tax revenue due to government, employment generation and consumer losses for purchasing non-durable and substandard products (Okorie and Humphrey, 2016). This is partly due to the fact that these goods are largely smuggled into the Nigerian markets, and avoid payment of duties as well as standardization checks.

Premise on the foregoing, this thesis provides answersto the following emerging questions:(1) Does environmental efficiency in Nigeria, as well as those in the partners' economies, influence bilateral trade between them? (2) Does this impact depend on the type of product traded?

1.3 Objective of the Study

The general objective of this study is to investigate the role of environmental efficiency in bilateral trade between Nigeria and her top trading partners. Specifically, the study seeks;

i. determine the impact of environmental efficiency on aggregate and sectoral imports of Nigeria fromAsia and the European Union
ii. estimate the impact of environmental efficiency on aggregate and sectoral exports of Nigeria to Asia and the European Union

1.4 Justification for the Study

Environmental issues have become an important part of the global production value chain and hence, critical in determining the composition and direction of trade. Consequently, environmental regulation and efficiency are increasingly becoming global issues which stakeholders are seeking theoretical and empirical explanations as well as policy implications for trade and sustainable development. However, despite the rising interest in the analysis of environmental issues around the world including its relationship with trade, a number of gaps stillexist.

In the theoretical literature, trade-environmental quality nexus has been explained using the classical and neo-classicaltheories of international tradein the context of the Ricardian and Hechsher-Ohlin modelsrespectively. These models have been modified to have derivative hypotheses that explain trade-environment nexus (porter and pollution haven hypotheses).However, the derivative hypotheses fail to accommodate the case of resource-rich developing economies, such as Nigeria,where comparative advantage are already developed in commodities produced from their abundant natural resources (and not labour or capital) which form a huge proportion of their export. Further, a major assumption in these modelsis that international market is free of distortion which is hardly observed in real world. Thus, available theories and models do not adequately explain how environmental efficiency could serve as a factor which improve or retard trade activities based on the existing level of comparative advantage.

This study attempts to fill this gap by expanding the Hecksher-Ohlin model to provide a role for environmental efficiency in a resource-rich developing country. This is done by relaxing the assumption of free trade (no trade distortion) while introducing environmental policy (much like tax and subsidy) that alters environmental efficiency level in production processes. This extension, which is operationalised using the gravity model of trade, is consistent with earlier work of Kohn (2000) where H-O model was expanded to incorporate the role of environmental tax. However, this study differs by focusing on the role of the environmental efficiency that could result from the effectiveness of such tax(outcome variable) rather than environmental tax (policy variable).

In terms of methodology, available studies (Xu, 2000; Harris et al, 2002; Cole and Elliott, 2003; van Beers and van den Bergh, 2000; Mulatu et al, 2004; Hering and Poncet, 2014; Costantini and Crespi, 2008; Doganay et al, 2014) dwelled on panel data framework where the dataset do not either exhibit zero trade flows or provide for the possibility of differences in the mean and variance of the bilateral trade distribution.The study differs from existing trade-environment studiesby adopting count data models, particularly the negative binomial Pseudo Maximum likelihood model which do not only overcome the shortcomings (multicolinearity, simultaneity, endogeneity) of other methods such as ordinary least square (OLS) but also account for the sources of zero bilateral trade flows and assume differences in the mean and variance of bilateral trade data.Also, most studies on environmental efficiency (Zhou et al, 2013;Wang et al, 2014;Wang et al, 2013; Chang et al, 2014; Song et al, 2015a; Li et al, 2013b; Doganay et al, 2014 and Chen and Jia, 2016) used both desirable (GDP) and undesirable outputs (carbon emission) together in a multiple-output DEA efficiency analysis. This combination does not incorporate the free disposability assumption where it is possible to reduce undesirable output whileholding desirable outputand the level of input constant or desirable output is increased keeping pollutants and the level of input the same. Recognizing this possibility is missing in the environmental efficiency-trade literature (Taskin and Zaim, 2001; Honma, 2015;Doganay et al, 2014 and Song and Zhou, 2015).

In an attempt to fill this gap, this study assumes free disposability which allows increase in desirable output (GDP) from the given amount of inputs while maintaining the level of pollution or reduce undesirable output (pollution level) from the same amount of inputs while keeping desirable output constant. Thus, desirable and undesirable outputs can be treated separately as output indicators to obtain the good efficiency scores and the bad efficiency scores respectively. The ratio of these two scores yields environmental efficiency according toHalkos and Tzeremes (2009).

In the empirical literature, studies that investigated environmental efficiency levels are quite extensive across regions and countries, although country-specific studies dominate. However, most studies that incorporated trade in their analysis (Xu, 2000;van Beers and van den Bergh, 2000;Harris et al, 2002;Cole and Elliott, 2003;Mulatu et al, 2004;Costantini and Crespi,2008 and Hering and Poncet, 2014)were only interested in the role of environmental regulation with results that are largely mixed. Among these studies, the only country-specific studies are those conducted for China (Hering and Poncet, 2014), Germany, Netherlands and USA (Mulatu et al, 2004). Despite the large body of studies as well as the rising interest in environmental issues, there appears to be limited studies onenvironmental efficiencyin Africa, and Nigeria in particular. Besides, very few studies are concerned with the impact of trade on environmental efficiency (Taskin and Zaim, 2001; Honma, 2015, and Song and Zhou, 2015) while only Doganay et al, (2014), investigated the impact of environmental efficiency on bilateral trade, appears to be close to the current study. However, Doganay et al, (2014) is limited, in terms of policy strength, as it was conducted for a panel of 111 countries using aggregate bilateral data and conclusions are hard to make for individual countries, both at aggregate and sectoral[5].

This study adds to the empirical literature by providing country-specific empirical evidence on the role of environmental efficiency in bilateraltrade relations between Nigeria and her top trading partners in Asia and the EU. The study also introduces sectoral dimension (mineral and non-mineral) into the trade-environment literature.

It is worthy of note that while this present study utilizes macro data, the possibility of firm-level analysis is acknowledged as different firms respond to environmental regulation differently, which may influence their international competitiveness. As revealed by the review of empirical literature, such analysis has been conducted by few studies and largely concentrate on single countries where firms are compelled to report the environmental implication of their activities (Goto et al, 2014and Song andZheng, 2015). Extending such firm-level analysis to bilateral trade relations among countries still remains a challenge in the literature which may explain why related studies dwell on macro data (Taskin and Zaim, 2001; Costantini and Crespi, 2008; Doganay et al, 2014; Hering and Poncet, 2014;Honma, 2015 and Song and Zhou, 2015). As noted by Doganay et al, (2014), firm-level analysis of environmental efficiency-trade link requires firms in all selected countries to report the level of environmental pollution associated with their production activities along with their export and import volumes. For many countries, including Nigeria, where firms often fail to respond or are not compelled to report such data, the cost implication for research of reaching local and foreign firms may be enormous. In line with most of the existing studies, this study therefore utilizes macro data for both the aggregate and sectoral analysis of the role of environmental efficiency in bilateral trade.

1.5 Scope of the Study

The study focuses on the role of environmental efficiency in bilateral trade between Nigeria and her top trading partners in Asia (excluding Middle East)[6] and the European

[5]Since some studies examine the effect of trade on environment, the possibility of reverse causality and simultaneity bias is accommodated in this study using the gravity model. This model is robust these problems simultaneity issues since they are basically reduced forms (Hamilton and Winters 1992). Moreover, this study treats the EU and Asian countries individually and not as a collective unit (Zhang and Kristensen, 1995).

Union.Apart from the total bilateral trade data, the study also aggregates sectoral data into mineral and non-mineral categories to minimize missing data issues.Seven countries in Asia (India, Indonesia, Japan, Korea Republic and Singapore) and ten in Europe are selected while datasets utilized for this study span (1996-2015)dueto data availability constraint. Based on United Nations (2020), all selected Nigeria's trading partners in Asia are in the South (India) and East (China, Hong Kong,Indonesia, South Korea andSingapore, including Japan) part of the continent.The selected European countries consist of members of the EU-15 (France, Germany, Italy, Netherlands, Portugal, Spain, Sweden and United Kingdom) plus Norway and Switzerland (EU+2, henceforth)[7].The choice of EU+2 and Asia follow their dominance in Nigeria's bilateral trade relations. The Top trading partners were selected based on data availability and according to their average share in Nigeria's total trade (export and import), as well as trade with the respective regions. According to World Trade Organization's Trade Profile Database, the EU+2 ranked as Nigeria's largest import source in 2014, while the emergence of Asia is reflected in the tremendous growth rate of its export to Nigeria.

1.6 Organization of the Study

This research work is organized in five chapters. Following the introduction, chapter two contains the background to the study and literature review where environmental policies across the various regions and Nigeria's bilateral trade agreements are discussed. The chapter presents the output and carbon emission levels across the trading partners, as well as their contributions to Nigeria's trade. It further presents the literature review where related existing studies are reviewed for relevant theoretical developments as well as methodological issues and empirical findings or evidence. The theoretical framework and methodology are developed in chapter three, while chapter four presents the results and discussion of findings. Chapter five summarizes the findings of the study and provides policy implications.

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[6] Based on data obtained from World Integrated Trade Solution (WITS), Nigerian trade with countries in the Middle East is very small, hence these countries may not qualify as Nigeria's top trading partners

[7] The study acknowledges the recent development within the EU regarding BREXIT, which sees the UK exiting the Union on the 31st January, 2020. The period of analysis however allows the inclusion of the UK as a member of the EU.

CHAPTER TWO

BACKGROUND AND LITERATURE REVIEW

2.1 Introduction

This chapter starts with a discussion of the evolution of non-tariff barriers to trade and the various environmental policies across different regions overtime. It further examines the various bilateral trade agreements between Nigeria and its trading partners before presenting stylised facts about output and carbon emission in Nigeria and its partners, as well as the trade relationship between them. It further provides a survey of theories, methodologies and empirical findings in the environment-trade literature.

2.2 Background to the Study

2.2.1World Trade Organisation (WTO) and Non-Tariff Barriers to Trade

Tariffs, which represent taxes imposed on commodities imports into a country, are one of the forms of government intervention in the functioning of the economy that has stood the test of time. They are often used as a policy instrument to protect the incomes of domestic producers from falling due to the presence of foreign competition. The economic costs of such protection include payment of higher prices for import-competing goods, and the associated inefficient allocation of resources in the import competing domestic industry. In most developed economies, thehigh average tariff on manufactured goods, which exceeded 30% after 1948,led these economies to agitate for reduction in these tariffs in a number of rounds of negotiations under the General Agreement on Tariffs Trade (GATT).The GATT, which was an international agreement concluded in 1947, governed trade in goods through rules and obligations, especially amongmember nations that are party to the agreement (The Contracting Parties). Between 1947 and 1994, eight rounds of negotiations were organized by the contracting parties with the eighth round leading to the creation of the World Trade Organization (WTO).

Following the Tokyo Round (1973-1979) where non-tariff barriers to trade (NTBs) was first mentioned, NTBs (also called technical barriers to trade) have become important part of trade discussions among stakeholders at all levels of trade negotiations. The Technical Barriers to Trade (TBT) Agreement of the WTO ensures that standards,technical regulations and conformity assessment procedures are fair(non-discriminatory) and creates no obstacles to internationaltrade. At the same time, the agreement recognizes the right of members of WTO to design and implementmeasures which assist in achieving legitimate policy objectives, especially if the aim is to protect human safety and health, as well asto protect the environment, although the measures for environmental protection were formally addressed by the TBT Agreement of GATT in 1994.

Thus, the WTO Agreement on the use of Sanitary and Phytosanitary Measures (SPS Agreement) seeks to reach an optimal position (balance) between the right of WTO members in protecting the health of their citizens and the need for unhindered movement of goods across borders.Environmental quality is a major aspect of production and trade across borders. As much as countries formulate various Sanitary and Phytosanitary measures and standards for goods they imports, they equally want to promote the quality of the environment to enhance product quality and remain competitive in the international markets in terms of environmental standards of internationally traded goods. In recognition of the important role of the environment on the health and productivity of labour as well as the possible transmission to other countries through trade, a number of environmental policies and measures have been formulated across major regions of the world[8].

2.2.2Environmental Pollution in Nigeria

Environmental concernshave dominated policy debates in Nigeria. Nigeria is a major producer of primary emissions such as sulfur oxides (SOx), nitrogen oxides (NOx), carbon monoxide,carbon dioxide (CO2), volatile organic compounds (methane and non-methane),chlorofluorocarbons (CFCs) and odours from garbage sewage, and industrial processes.These emissions contribute enormously to greenhouse gas with the

[8]For more discussion on TBTs, see WTO (2014b) and WTO (2014c)

attendingunwantedimpact on the environment and human health.As depicted in Figure 2.1, total greenhouse gas emission in Nigeria has remained above its 1990 values reaching as high as 129% (relative to the 1990 values) in 2005.

This high positive growth in greenhouse gas is driven by the similar change in the major components of this gas in Nigeria. For instance, while the rise in methane emissions from its 1990 values hovered around 27% and 38%between 1996 and 2012 having reached a peak of about 43% in 2006, nitrous oxide emissions grew continuously from about 4% to 86% over the same period (Figure 2.2a). Moreover, carbon emission appears to be the largest major contributor to greenhouse effect in Nigeria rising from a growth of 1% (relative to 1990 carbon emission values) in 1996 to 152% and 151% in 2006 and 2012 respectively. For other components, available data also shows that sulphur hexafluorocarbon (SF6) rose by about 137% between 1998 and 2008 while hydrofluorocarbon (HFC) rose by over 550% during the period 2000-2014. When this is compared to Nigeria's trading partners, carbon emissions remain the largest source of greenhouse emission across all the countries in 2012 (Figures 2.2b and 2.2c). However, while most of the selected top partners in Asia have similar positive growth of all types of emission since 1990, most of the countries in the EU+2 recorded negative growth reflecting the effectiveness of environmental policies in the region over the years.

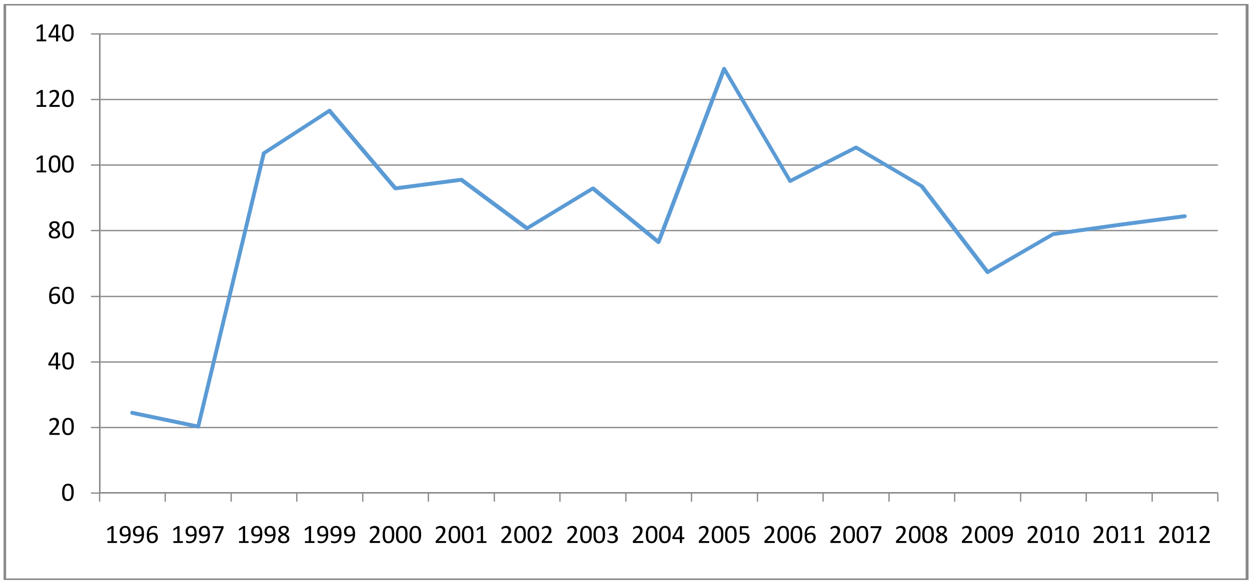

Figure 2.1. Total Greenhouse Gas Emissions in Nigeria (% change from 1990)
Source: Author's Computation; Data from World Bank WDI (2017)

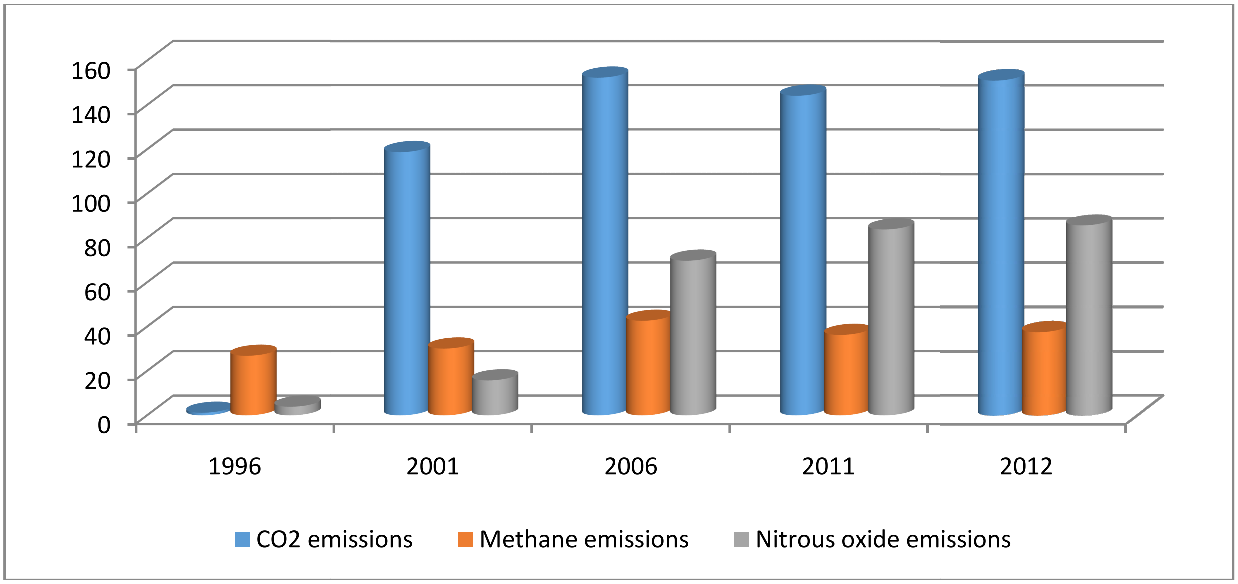

Figure 2.2a. Components of Greenhouse Gas Emissions in Nigeria (% change from 1990)
Source: Author's Computation; Data from World Bank WDI (2017)

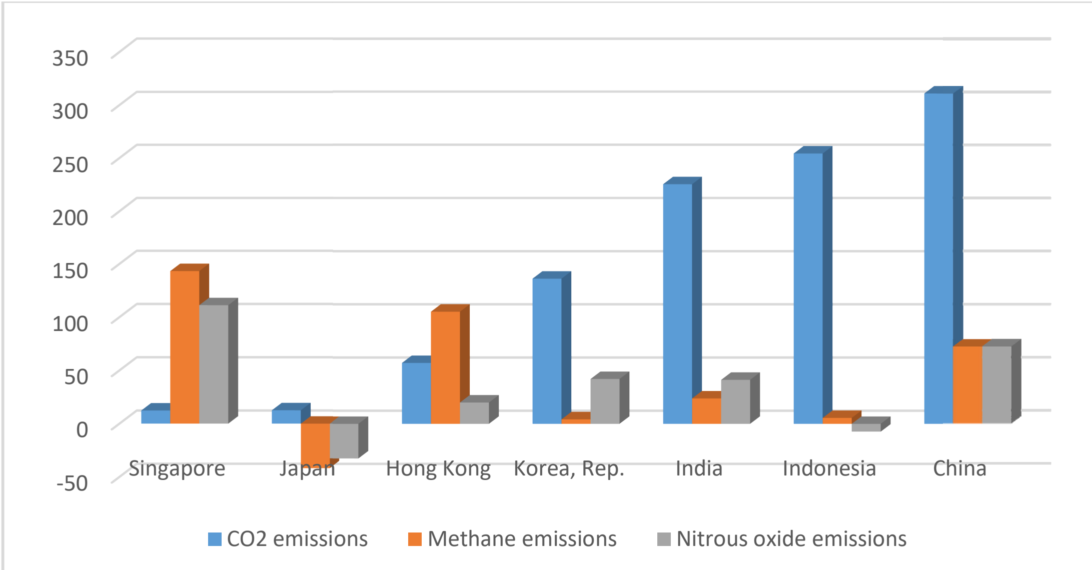

Figure 2.2b. Components of Greenhouse Gas Emissions in Asia (% change from 1990)
Source: Author's Computation; Data from World Bank WDI (2017)

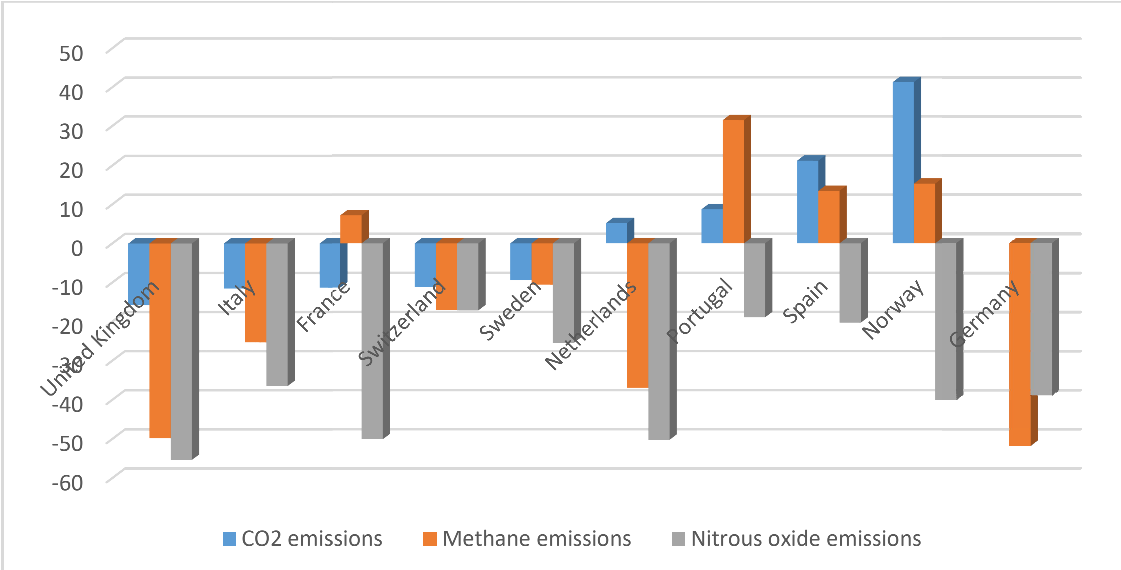

Figure 2.2c. Components of Greenhouse Gas Emissions in the EU+2 (% change from 1990)

Source: Author's Computation; Data from World Bank WDI (2017)

In Nigeria, consideration of anthropogenic sources has largely originated fromthermal plants (Sonibare, 2010), vehicular emissions (Fakinle et al, 2013 andOjuri et al, 2016) and petroleum and oil industries (Oladimeji et al, 2015 andSonibare et al, 2007).The major sources of carbon emissions in the country are presented in Table 2.1. The transport sector appears to be the largest contributor to carbon emission in Nigeria recording over 40% of emissions generated from fuel combustion in the country for almost all the period 1996-2014.This could reflect the heavy reliance on road transport in the country for transporting goods produced from all sectors, including oil and gas. However, while carbon emission from transport activities declined in recent years, those from electricity and heat production rose from about 32% in 1996 and 28% 2001 to almost 40% in 2014. Also, carbon emissions from manufacturing and construction activities rose from about 10% in 1996 to over 12% in 2014 following a major decline in 2001. This therefore implies that carbon emission comes from almost all economic activities in Nigeria reinforced by the increased use of transportation.

Another critical source of greenhouse gas is gas flaring from the Nigerian oil and gas sector. This source does not result from combustion of fuel rather it is produced alongside oil production in the country as associated gas (AG). Gas flaring is a major source of global warming, contributing to emissions of carbon monoxide, nitrogen (II) oxide and methane which have the propensity of causing environmental pollution and ecological disturbances or destruction. Notwithstanding, gas flaring in Nigeria reduced noticeably over the period 1999-2014 falling from about 50% in 1999 of the total gas produced to about 5% in 2014 (Table 2.2).

Oil companies continue to represent a major contributor to routine flaring of associated gas which has been carried to world record height. Flaring has been declared illegal since 1984 as contained in section 3 of the Associated Gas Reinjection Act, 1979 where companies are allowed to flare only in the event that they possess field-specific and lawfully-issued ministerial certificates. Theses flares, which have led to higher levels of greenhouse gases (and climate change) than those emitted by the combined Sub Saharan African countries, contain toxins that affect the health and livelihood of communities, especially the high-risk areas such as the Niger Delta who faces child respiratory illnesses, cancer, premature deaths and asthma (ERA, 2005).

Table 2.1. Sources of Carbon Emission in Nigeria (% of total fuel combustion)

Year	Electricity and heat production	Manufacturing industries and construction	Transport	Residential buildings, commercial and public services	Other sectors	Total Fuel combustion
1996	31.86	9.67	47.05	11.37	0.05	100
2001	28.46	5.26	53.82	10.69	1.78	100
2006	32.95	9.31	47.42	4.80	5.51	100
2011	36.23	11.64	40.75	3.87	7.51	100
2012	37.34	9.61	40.22	2.47	10.35	100
2013	36.82	10.47	38.75	2.56	11.41	100
2014	39.06	12.18	35.39	2.61	10.75	100

Source: Author's Computation; Data from World Bank WDI (2017)

Table 2.2.Gas Produced and Gas Flared in Nigeria (mscf)

Year	Gas produced (billion)	Gas flared (billion)	% of gas flared
1999	1.33	0.79	50.64
2000	1.62	0.88	54.07
2001	1.82	0.92	50.52
2002	1.65	0.74	45.05
2003	1.83	0.85	48.31
2004	2.04	0.86	41.96
2005	2.05	0.78	37.92
2006	2.13	0.75	35.42
2007	2.04	0.60	29.29
2008	2.12	0.54	25.47
2009	1.63	0.44	26.55
2010	2.20	0.51	23.12
2011	2.23	0.56	24.98
2012	2.31	0.59	25.47
2013	1.93	0.59	30.53
2014	2.52	0.29	11.47

Source: Author's Compilation fromNigerian National Petroleum Corporation (NNPC) Annual Statistical Bulletin (2005, 2010, 2015)

2.2.3 Environmental Efforts

2.2.3.1Global Environmental Efforts

Following the increased awareness of governments and stakeholders on the adverse effect of environmental degradation on the health of man and its environment, interest on environmental issues has become pronounced over the years. Global efforts towards reduction of environmental pollution as well as mitigating its effect became prominent about four or five decades ago.

The first noticeable gathering of international community on global environmental issues was convened in 1972 during the UN Conference on Earth and Environment held in Stockholm with the main objective of discussing global environmental concerns. United Nations Environment Program (UNEP) was established at the Stockholm Convention. In 1980, theInternational Union for Conservation of Nature(IUCN)started efforts to help countriesplan for the protection and maintenance of water, soil, wildlife andforests. In 1987, the UN World Commission on Environment and Development highlightedsustainable development as a novel idea, focusing on ecologically balanced and conservation-oriented economic development which became a dominant ideal in international development programs.

The Montreal Protocol on Substances that Deplete the Ozone Layer was a giant stride in the efforts to reduce production and consumption of substances that deplete the ozone. This was aimed towards reducing thesesubstances in the atmosphere, protecting the fragile ozone layer of the earth. Originally, the Montreal Protocol was agreed on 16 September 1987 and entered into force on 1 January 1989. World leaders gathered again at the United Nations Conference on Environment and Development in Rio de Janeiro in June 1992further discuss substances that are injurious to the earth as set forth in the Brundtland Report. The Rio "Earth Summit" addressed a number of global environmental problems ranging from global climate change, resource depletion, and pollution. Consequently, a number of ratified agreements designed to tackle some of these seemingly intractable issues were signed including the Convention on Biological Diversity and Climate Change Convention. The Climate Change Convention in turn led to the Kyoto Protocol and the Paris Agreement.

The negotiation of the Kyoto Protocol treaty took place in Kyoto, Japan in December 1997 and came into force February 16th, 2005.The treaty currently has 192 parties, with Canada withdrawing its membership in December 2012[4].The protocol is an agreement, which is legally binding, and admonished industrialized countries to cut down collective emissions of greenhouse gases by 5.2% relative to the year 1990. The goal of the protocol is to reduce overall emissions from six greenhouse gases including methane, HFCs,sulfur hexafluoride, carbon dioxide, PFCs and nitrous oxide, over the five-year period of 2008-2012.The first commitment covered the period 2008-2012. During the second commitment (Doha Amendment to the protocol) period, which was agreed in 2012, 37 countries (Australia, the European Union (28), Belarus, Iceland, Kazakhstan, Liechtenstein, Norway, Switzerland and Ukraine)set binding targets.

The Paris Agreement (Accord de Paris), is an agreement within the United Nations Framework Convention on Climate Change (UNFCCC) to deal with greenhouse gas emissions. Specifically, it seeks to mitigate this emission, with adaptationand finance to start in the year 2020. As of June 2017, 195 UNFCCC members have signed the agreement, with 153 ratifying it. While the Agreement sought to strengthen the response of global stakeholders to the threat of climate change. It also aimed to strengthen countries'ability to deal with the influence of climate change. Appropriate financial flows, an enhanced capacity building framework and a new technology framework is expected to drive the process especially in developing countries and the most vulnerable countries[9].

Following the global concerns on environmental degradation, the various global stakeholders' meeting spurred many countries into action to improve the quality of the environment. The Environmental Performance Index (EPI) rankings ranks countries on the basis of how they are addressing the environmental challenges that every nation faces (Wendling et al (2020). It provides a way to spot problems, set targets, track trends, understand outcomes, and identify best policy practices.Figure 2.3 shows the EPI scores

[9] Further details of these global efforts can be found in the following pages: https://en.wikipedia.org/wiki/Paris_Agreement (Wikipedia, 2018a); https://en.wikipedia.org/wiki/Kyoto_Protocol (Wikipedia, 2018b); http://www.kyotoprotocol.com/; http://unfccc.int/paris_agreement/items/9485.php

for Nigeria and her top trading partners in 2020. All Nigeria's top partners in Europe, except Portugal (67), scoredabove 70 and are ranked in the top 20 globally. Japan is the only Nigeria's Asian partner in the top 20 with a score of 75.1, and ranked 12 globally. This country performs better than Spain (74.3) and Italy (71) who are ranked 14 and 20 respectively. The Selected countries in Asia largely trails their European counterparts on the EPI ranking with India performing the worst after ranking 168 from a score of 27.6. This is closely followed by Nigeria (31), China (37.3) and Indonesia (37.8) which ranked 151, 120 and 116 respectively.Thus, progress in environmental management remains critically deficient in Nigeria and her top trading partners in Asia such as India, China and Indonesia while good progress has been recorded across Nigeria's partners in the EU+2, including Switzerland and Norway.

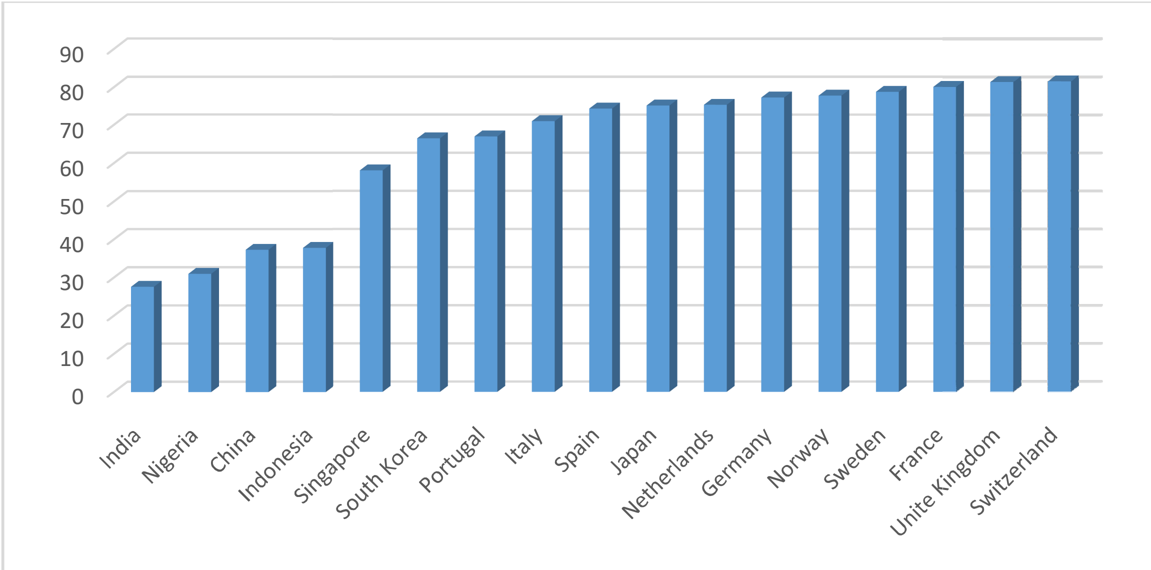

Figure 2.3.Environmental Performance Index in Nigeria and her Top Partners
Source: Author's Computation based on data from the UNDP, 2020

2.2.3.2Environmental Policies in Nigeria

Prior to 1988, there appears to be little or no public awareness regarding environmental protection and development in Nigeria, as environmental issues were not serious concerns in the agenda of the various governments.The Federal Government of Nigeriahas however promulgated various laws and Regulations to safeguard the Nigerian environment since then. The Federal Environmental Protection Agency Act of 1988 (FEPAAct), which represents a major effort towards addressing environmental concerns in the country, made a number of National Environmental Protection Regulations. These regulations include The National Policy on the Environment (1989), National Effluent Limitation Regulation (1991), Pollution Abatement in Industries and Facilities Generating Wastes Regulation (1991), National guidelinesand Standard for Environmental pollution Control inNigeria (1991)andManagement of Solid and Hazardous Wastes Regulations (1991). Other environmental laws include the Harmful Wastes (Special Criminal Provisions etc.) Act of 1988 (Harmful Wastes Act) and the Environmental Impact Assessment Act of 1992 (EIA Act). Particularly, section 2 of the Environmental Impact Assessment Act of 1992 (EIA Act) implies that the public or private sector of the economy must consider the impactof projects or activities on the environment before authorizing such projects. Some of these regulations which have specific focus on industrial activities are further discussed in what follows.

a. National Effluent Limitation Regulation

The Federal Environmental Protection Agency Act of 1988 (FEPAAct) introduced the National Effluent Limitation Regulation in 1991. The regulation holds that every industry must install anti-pollution equipment which will enhance the detoxification of effluent and chemicaldischarges which emanates from the industry, and should be based on the Best AvailableTechnology (BAT), the Best Practical Technology (BPT) or the Uniform Effluent Standards (UES). Also, an industry which discharges effluent to the surrounding water must treat the effluent to a specified uniform level to ensure assimilation by the receiving water into which the effluent is discharged.According to the regulation, if a firm violates anyof the provision of these regulations, such is adjudged guilty of an offence and will be convicted to thepenalty as specified by the Federal Environmental Protection Agency Act.

b. Pollution Abatement in Industries and Facilities Generating Wastes Regulation

This regulation was promulgated in 1991 by the Federal Environmental Protection Agency Act of 1988 (FEPAAct). The regulation provides that no industry or facility shall release hazardous or toxic substances into the air, water or land of Nigeria's ecosystemsbeyond limits approved by the Agency. Hence, the regulation holds that an industry or a facility must have a pollution monitoring unit within its premises and must also have an on-site a pollution control. Moreover, such industry or facility is mandated to assign responsibility for the control of pollution to a person or corporate body which must be accredited by theAgency. The regulation also encourages prompt, usually within 24 hours, reports of an unusual or accidental discharge of waste. Firms are required to make available to FEPA the list of chemicals stored and used in the manufacture of its products while providing a contingency plan which must be approved by the Agency against accidental release ofpollutants.It therefore becomes important for industries to set up machineryin order to mitigate pollution hazard while maintainingequipment in the event of an emergency.

In order to protect residential areas from harmful substances, each state in Nigeria must provide industrial layouts which should be separate from areas of residence, and as such provide buffer zones between industrial layouts and residential areas. The regulation further empowers FEPA to prevent a facility from starting operation where such may pose a potential pollution source. According to the regulation, if an industry or a facility is a potential source of gaseous, particulate, liquid or solid untreated discharges, then such facility must install appropriate abatement equipment.

c. Management of Solid and Hazardous Wastes Regulations

The regulation on solid and hazardous waste was also promulgated in 1991 by FEPA to identify solid, toxic and extremely hazardous wastes that are dangerous to the health of the public andenvironment, and to provide facilities that will enhance the surveillance and monitoring of such dangerous and extremely hazardous substances. The regulation also provides necessary requirements which is important towards facilitating the disposal of hazardouswastes, while providing conducive environment and incentives to conduct research into possible re-use and recycling of these wastes. It requires all industries toinform FEPA of all toxic, hazardous and radioactive substances kept in theirpremises and discharged during their production process. The regulation allows FEPA to set up regional bodies or committees to serve as "dump watch" for transboundary movement oftoxic, hazardous and radioactive waste.

Further, the regulation provides the procedures for the determination of wastes which contain halogenated hydrocarbons (HH) and/or polycyclic aromatic hydrocarbons(PAH) withmore than three rings and less than seven rings.An industry is required to assess the level of HH and PAH in its waste by following specified guidelines provided by the Agency.

d. Environmental Impact Assessment Act

The Environmental Impact Assessment Act (1992) was promulgated by FEPA with the main objectives of compel industries to undertake an assessment of the environmental consequences of their operation before embarking of such activity. Thus, a firm must take into account the environmental effect of their activities before a project decision is taking. The regulation also provides restriction on public as well as private facility where no undertaking is allowed without prior considerationof their implication on the environmental, especially at an early stage. The Federal Ministry of Environment released a number of guidelines which enables effective administration of the FEPA and EIA Acts and procedures which are useful for evaluating environmental impact assessment reports (EIA Reports).Other regulatory agencies were also set up to provide oversight functions over specific industries who have in turn issued guidelines to regulate the impact of such industries on the environment. Examples of such guideline include the Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN) 2002, published by the Department of Petroleum Resources (DPR). In the same vein, each State and local government in the country were also encouraged to make environmental laws set up its own environmental protection body or agency for the protection and improvement of the environment within the State[10].

e. **The Renewable Energy Programme**

The Federal Ministry of Environment initiated the Renewable Energy Programme as part of the obligation of the Federal Republic of Nigeria to the United Nations Framework Convention on Climate Change (UNFCCC). It is also in fulfilment of the African strategy on voluntary emission reduction. The initiative aims to encourage everysectors of the economy to gradually move to cleaner sources of energy towards the achievement of the objectives of the Vision 20:2020.Thus, in April 2012, Nigeria became a State Partner in the Climate and Clean Air Coalition (CCAC) to mitigate Short-Lived Climate Pollutants (SLCPs), where the initial focus was on methane, hydroflourocarbons (HFCs) and black carbon. Among Nigeria's partnership efforts include Bank of Industry/UNDP Access to Renewable Energy Programme,Inter-Ministerial Committee on Renewable Energy and Energy Efficiency (ICREEE), Nigeria-German Energy Partnership, Nigeria-Nordic (Sweden, Finland & Norway)Energy Forum, Nigeria-India Partnership on Renewable Energy development[11].

The Renewable Electricity Policy Guidelines (REPG) was developed by the Federal Ministry of Power and Steel in December, 2006 to promote the use of renewables in the power sector. It mandated the Nigerian government to expand electricity generation from renewable sources to at least 5% of the total electricity generated and at least 5 TWh of electricity generation in the country. Also, the Renewable Energy Master Plan (REMP) was developed by the Energy Commission of Nigeria (ECN) in 2005, in collaboration with the United Nations Development Programme (UNDP). The plan was later reviewed

[10]Makinde and Adeyoke. (2007)and George Etomi& Partners (2014)
[11]This report is found on the website of the Nigerian Ministry of Environment - http://www.environment.gov.ng/index.php/our-initiatives/clean-energy-initiatives

in 2012. The REMP seeks to increase the contribution of renewable energy towards sustainable development and reverse environmental change across the world[12].

f. Other Environmental Efforts in Nigeria

The Federal Ministry of Environment (FME) took over the administration and enforcementof environmental laws in Nigeriafrom the Federal Environmental Protection Agency (FEPA)in 1999 created under the FEPA Act. The 1999 Constitutionof the Federal Republic of Nigeria provides the groundfor environmental policy in Nigeria. The Constitution empowers the State to protect and improve the environment while safeguarding the land, water, forest, air and wildlife.

Administered by the Ministry of Environment, the Federal Environmental Protection Agency (FEPA) Act was replaced by the National Environment Standards and Regulation Enforcement Agency (NESREA) Act of 2007.The Agency embodiesthe laws and regulations which is aimed at the protection and sustainable development of the environment as well as its natural resources. The Act also ensure that all environmental laws, local and international, on environmental sanitation and pollution are well complied with while providing monitory and regulatory procedures.The Agency is also empowered to make and review regulations regarding air and water quality, as well as other pollution issues ranging from effluent limitations, control of harmful substances and other forms of environmental pollution and sanitation. In addition, without lawful authority, the Agency prohibits hazardous substancesdischarge. Other notable regulations under NESREA includethe Nigerian Urban and Regional Planning ACT CAP N138, LFN 2004; Harmful Waste (Special Criminal Provisions) ACT CAP H1 LFN 2004; Hydrocarbon Oil Refineries ACT, CAP H5, LFN 2004 andOil in Navigable Waters ACT, CAP06, LFN 2004[13].

Despite the array of environmental policies in Nigeria, environmental degradation still remains a major issue. It is therefore true that while laws and regulations are good, enforcement, which is often lacking, is much more critical for sustainable development in the country. In fact, the Federal Ministry of Environment (2016) partially attributed the

[12] Iwayemi et al, (2015); ECN and UNDP. (2005, 2012); ECN and FMST. (2014)
[13] ELRI (2011)

much greater environmental pollution in recent years compared to previous decades the ineffectiveness of the institutional, logistical and policy arrangements that have been put in place over the years to tackle the menace.

2.2.3.3 Environmental Policies in Asia

Over the past three to four decades, control of environmental pollution has been very weak in Asia. The recent rise in industrial activities, following the emergence of the Asian Tigers (HongKong, Singapore, South Korea and Taiwan), as well as countries such as China andIndia,contributed immensely to the rising menace of environmental degradation in the region. This development raisedserious concerns and inspired efforts of governments and stakeholders to mitigate the problems.

The South Asian countries have been actively involved in regional cooperation on environmental issues. This includes the 1972 UN Conference on Human Security held in Stockholm and the UN Conference on Environment and Development, held in Rio in 1992, as well as the signing of several global and regional protocols on environment. The involvement of these countries in the various regional efforts has enabled them to record some growth in environment protection activities such as the establishment of full-fledged Ministries of Environment and preparation of environmental policies and strategies as well as action plans on environmental issues which include air pollution,climate change, energy conservation, the ozone layer, and efficiency, development of renewable sources of energy among others. Moreover, a number of environmental NGOs and civil society organizations have emerged in South Asia.

In South Asia, the notable inter-governmental organizations on environmental issues are the South Asian Association for Regional Cooperation (SAARC), the South Asia Cooperative Environment Programme (SACEP) and the South Asia Regional Seas Programme. In particular, SAARC was established in 1985 as a response to environmental concerns and challenges in the region. The cooperation adopted the first SAARC Environment Action Plan in 1997 while the meeting in 2008 a Declaration and an Action Plan on Climate Change were adopted prior to the 2009 climate change meeting in Copenhagen.

The Association of Southeast Asian Nations (ASEAN)Agreement on Transboundary Haze Pollution represents a cooperative action to bring the smoke haze caused by forest burning under control. The agreement allows for regional and bilateral cooperation and calls for greater transparency and accountability on the part of land owners and companies. In 2015, Indonesia was the last ASEAN member to ratify the agreement. Regional agreements were implementedamong these nations both for climate change mitigation and prevention of damages to public health which emanated from the release of short-lived climate pollutants and other toxic pollutants (mercury and polycyclic aromatic hydrocarbons).

Furthermore, Japan, China and the Republic of Korea face common environmental challenges. Thus, the Environmental Ministers of these countries established the Tripartite Environment Ministers Meeting (TEMM). The meeting has played critical role as a regional high-level cooperation mechanism on the environment in North-East Asia, with the first action plan implemented between 2010 and 2014 while a new 5-year action plan was adopted in 2015. Among the priorities of this new plan include conservation of water and marine environment, climate change response andair quality improvement.

The bulk of production and consumption in Asia is dominated in a few resource-scarce economies such as India, Japan,Thailand,Indonesia, China,Malaysia, Republic of Korea, and Viet Nam (UNEP, 2013). In most of these economies, a number of strategies have been designed to manage resources efficiently with huge steps towards minimizing wastes and protecting the environment within their territory. In Asia, regional integration/cooperation is on the increase in the quest for green economies. Examples of such organization include Pacific Economic Cooperation (APEC), Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC), Pacific Islands Forum (PIF), Economic Cooperation Organization (ECO),Asia Greater Mekong Sub-region (GMS)and Trans-Pacific Partnership (TPP). In Asia and the Pacific, the green growth agenda was initiated to assist governments to shift from unsustainable production and consumption patterns to more sustainable pathways.Priorities are also shifting regionally towards a resource and environmentally efficient society as evident in the 2009 Manila Declaration on Green Industry in Asia; 2010 Ministerial declaration on environment and development in Asia and the Pacific; the Sustainable 3R Goals for Asia and the Pacific for 2013–2023; and the 2007 ASEAN Declaration on Environmental Sustainability.

2.2.3.4 Environmental Policies in the European Union

In the European Union (EU), environmental policy usually focuses on the management and control of pollution at the source, hence, it is based on "precautionary principle" (Swiss Re - Centre for Global, 2014). The EU usually undertakes environmental policies both at the collective and at the individual Member States levels, with high level of policy harmonization. Environmental protection laws in the EU Member States require pollution-intensive industries to access the impact of their activities and implement adequate risk protection and mitigation measures. For instance, the "polluter pays principle" is a popular concept implemented across the EU where firms have to pay for damage they cause through poor management of environmental risks. Among the comprehensively regulated areas are protection of nature,waste (disposal sites, incinerators, etc.), hazardous activities, and substances and air pollution.

The EU met its Kyoto targets of reducing their total greenhouse gas (GHG) emissions to 8% below 1990 levels by the period 2008-2012. According to the Eurostat, total GHG emissions in the EU have been reduced by 15.44% between 1990 and 2010. Following this success, the EU enacted in its 2009 Climate and Energy Package which specifies climate related targets for the year 2020.

Moreover, a number of emission-reducing and other environmental policies were undertaken by the EU. The EU established the EU Emission Trading System (ETS) to set legally binding cap on emissions by key industries while allowing each member state to implement individually designed measures for non-ETS sectors that must meet the set targets of the EU. The EU ETS was adopted in 2003 and was to be implemented in three faces between 2005 and 2020 and covers CO_2 emissions of the power and heat generating plants, and energy intensive industry sectors, as well as and nitrous oxide (N_2O) perfluorocarbons (PFCs) from specific production processes. Also, the EU agreed to emissions reductions of 50 Mt CO_2e by 2015 under the Methane-to-Markets partnership with US Environmental Protection Agency (EPA) in 2007. Under this partnership, hydrofluorocarbons (HFCs), PFCs and sulphur hexafluoride (SF6) are banned from certain products but regulated for safety in others.

In their quest to reduce greenhouse gases (GHG), the EU aims to achieve, by 2020, a 20% share of energy from renewable energy source in final energy consumption and a 10% share of energy from renewable sources (such as solar and biomass) in each member state's transport energy consumption. Thus, member states are encouraged to formulate renewable energy action plans, establishing targets for the share of renewable energy in transport, electricity, heating and cooling in 2020 and specifying the means of achieving the targets. In the same vein, the EU, in 2011, formulated the goal of reducing transport emissions by 60% by 2050 while member states were also mandated to establish certificates of energy performance buildings and introduce standards. The EU is also involved in financing and coordinating research and development (R&D) by industries such as the European Technology Platforms (ETPs) and The Intelligent Energy Europe (IEE)[14].

Another popular environmental effort and policy of the European Union is The European Commission Environmental Liability Directive (EC ELD). This directive, which began in 2010, was implemented to address environmental damage, especially in terms of prevention and remediation. This directive established a basic administrative and statutory liability framework that provides a platform for national laws to converge. The directive addresses liability for damage made to natural resources as well as biodiversity, and sets binding, minimum standards that must be transposed by the Member States into legislation, but some other elements are elective[15].

2.2.4 Nigeria's Bilateral Trade Agreements

Bilateral relations with Asia and the EU+2 date back to more than four decades ago over which series of economic and developmental agreements were discussed and signed. These relations have expanded on growing bilateral trade and strategic cooperation between Nigeria and economies in these regions. For instance, the joint Communiqué on

[14] Comprehensive discussion of these policies and programmes are contained in various reports such as Landis et al (2012), Busenhart(2014), EEA (2014) and EEA (2016).

[15] The most important elements of the EC ELD is contained in Swiss Re - Centre for Global (2014)

the Establishment of Diplomatic Relations between the People's Republic of China and the Federal Republic of Nigeria was signed in February 1971.Following the adverse trade imbalance and falling foreign reserves in the mid to late 1970, the two countries agreed to cooperate in the fields of agriculture, industry and trade and China committed to buy palm kernels, cocoa, cashew nuts and cotton from Nigeria after the negotiations in 1978 (Owoeye, 1986). In May 1997, the two countries reached and signed agreements on oil cooperation where China expressed interest in purchasing Nigerian crude oil for the purposes of blending and to participate in the petrochemical industry (Chibundu 2000).

In August 2001, the two countries signed the Agreement on Trade, as well as Investment Promotion and Protection between the Government of the People's Republic of China and the Government of the Federal Republic of Nigeria. Also, in April 2002, the two governments signed the Agreement for the Avoidance of Double Taxation and the Prevention of Fiscal Evasion with respect to taxes on income. About three months later, the two governments proceeded to sign the Agreement on Consular Affairs, the Agreement on Cooperation on Strengthening Management of Narcotic Drugs, Psychotropic Substances and Diversion of Precursor Chemical, and the Agreement on Tourism Cooperation[16].To consolidate existing bilateral relations, Nigeria and China signed a Memorandum of Understanding (MOU) on petroleum cooperation which provides for substantial Chinese investment in the Nigerian oil industry in 2006 (Udeala, 2010). The two countries also signed a double taxation agreement in 2010.

Japan established diplomatic relations with Nigeria in 1964 after which economic relations grew dramatically. However, there appears to be no concrete bilateral trade agreements between the two countries until the signing of a Memorandum of Understanding (MoU) between the two countries that would boost trade agreement and bilateral relations in 2010 by The Nigerian Investment Promotion Council (NIPC) and the Japanese External Trade Organisation (JETRO).India established diplomatic mission in Nigeria in 1958. Following a number of governmental and official visits beginning from 1999, the Abuja Declaration of Strategic Partnership Agreement was signed in 2007 to further enhance bilateral cooperation and collaboration. About nine of MOUswere also

[16]Embassy of the People’s Republic of China in the Federal Republic of Nigeria. (2004).

agreed in 2008 which include those on Double Taxation Avoidance, Bilateral Investment promotion and protection and Bilateral Trade Agreement.

Economic and development relations between the EU+2 and Nigeria dates back to 1975 when Nigeria joined the African, Caribbean and Pacific (ACP) group of states as a signatory to the Lomé Convention. However, this relationship was suspended in 1995 following the execution of nine Ogoni rights activists by the then military government. The Cotonou Agreement was revised in 2005 and 2010. Since 2000, the Agreement has been the framework for EU relations with 79 countries from these regions including Nigeria. This agreement forms the legal basis for Nigeria and the EU's partnership on a number of areas including political issues, development cooperation and trade. The Agreement was supposed to be followed by the Economic Partnership Agreement (EPA) between the EU and ACP countries, which The Gambia and Nigeria are the only Economic Community of West African States (ECOWAS)members that are yet to sign[17].Nigeria has comprehensive double taxation agreements with France (1992), the Netherlands (1993)and the United Kingdom (1989). These treaties apply to personal income, corporate income, capital gains, and petroleum profits. Other treaties and negotiations include those with Norway and Sweden.[18]

2.2.5Environmental Efficiency, Carbon Taxes and Business Cost Indicators

Production activities generate environmental pollution, the cost of which firms can internalize by taking responsibility for this associated negative externality or neglect by overlooking the adverse effect of their activities on the society. Environmental regulations are often put in place to ensure that firms internalize the cost of environmental impact of the production process, the result of which is reflected in lower emission per GDP.

As shown in Table 2.3, carbon emission per dollar of output produced fell over the period 1996-2015 in all the selected countries except Norway where there was a slight increase from about 0.103 kilograms in 1996 to about 0.166 kilogram in 2015. Among Nigeria’s top EU+2 trading partners, Switzerland appear to generate the least carbon emission per

[17] The other members of ECOWAS are Benin, Burkina Faso, Cape Verde, the Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Senegal, Sierra Leone, and Togo.
[18] EIU (2010).

dollar of output produced, followed by Sweden, Norway and France in that order. United Kingdom and Germany were able to reduce carbon emission per dollar output significantly from 0.303 kilogram and 0.311 kilogram in 1996 to 0.174 kilogram and 0.202 kilogram respectively in 2015. Generally, the EU+2 appears to be more environmentally efficient than Asia as each dollar of output produced in an average selected Asian economy generated more carbon emission than most selected EU+2 country.

In Asia, China generated more carbon emission per dollar of output than any other Nigerian top partner in Asia recording about 1.078 kilogram in 2015, followed by India and Korea, although some improvement is evident over the selected period (1996-2015). As observed from Table 2.3, Nigeria boasts lower carbon emission per dollar of GDP than almost all the selected Asian countries except Hong Kong and Japan but this emission remained higher than those of most EU+2 countries. Most of these countries adopted carbon pricing as a way of compelling companied to be conscious of the environmental impact of their activities while encouraging them to adopt carbon-efficient techniques.

According to OECD (2018), the carbon pricing gap may reflect the long-run competitiveness of firms and countries. A zero or very low gap sends signals of potential decarbonisation process of an economy to investorswhile its companies have adequate incentives to compete favourably in a low-carbon economy. Thus, the lower the gap, the more firms internalize the environmental cost of production. This development increases the cost of production of firms, especially in the short-run as all agentsinternalizes carbon costs in their business decisions, and it becomes costly to sustain the behavioural bias of ignoring the low carbon transition. Thus, firms have to pay huge tax or increase investment in carbon-efficient production techniques. In turn, it also suggests that the government increases their commitment to providing improved, low cost business environment that reduces the cost of production both to the firm and to the society in the long-run while increasing the competitiveness of the economy in world trade.

Table 2.3. Carbon Emission per GDP in Nigeria and the Selected Partners

	1996	2001	2006	2011	2012	2013	2014	2015
Nigeria	0.276	0.507	0.351	0.248	0.247	0.225	0.203	0.205
Europe								
France	0.182	0.158	0.144	0.123	0.123	0.122	0.124	0.122
Germany	0.311	0.269	0.245	0.207	0.208	0.212	0.204	0.202
Italy	0.225	0.215	0.213	0.186	0.178	0.169	0.188	0.185
Netherlands	0.285	0.224	0.206	0.203	0.201	0.202	0.203	0.199
Norway	0.103	0.112	0.106	0.104	0.112	0.133	0.118	0.116
Portugal	0.270	0.278	0.255	0.204	0.205	0.208	0.216	0.208
Spain	0.241	0.249	0.247	0.191	0.192	0.175	0.194	0.184
Sweden	0.166	0.127	0.105	0.103	0.094	0.088	0.092	0.090
Switzerland	0.092	0.088	0.077	0.062	0.063	0.066	0.063	0.062
United Kingdom	0.303	0.256	0.221	0.182	0.187	0.180	0.178	0.174
Asia								
China	2.130	1.439	1.594	1.455	1.390	1.320	1.113	1.078
Hong Kong	0.207	0.246	0.208	0.183	0.178	0.179	0.167	0.163
India	1.358	1.224	1.062	1.045	1.082	1.023	0.877	0.827
Indonesia	0.537	0.628	0.573	0.715	0.705	0.534	0.536	0.524
Japan	0.231	0.224	0.214	0.209	0.213	0.211	0.201	0.201
Korea, Rep.	0.683	0.607	0.500	0.519	0.503	0.496	0.460	0.458
Singapore	0.503	0.372	0.166	0.153	0.210	0.186	0.160	0.162

Source: Author's Computation; Data from World Bank WDI (2017)

Figure 2.4 show the carbon pricing gap among the selected countries, which measures how much each economy fall short of pricing carbon emissions in line with a benchmark value for carbon prices. In line with the submission of OECD (2018), it becomes obvious that low-gap countries also produce fewer emissions. For instance, Switzerland had the lowest carbon gap of 27% in 2015 and produced carbon emission per dollar of output that ranged from 0.092 kilogram in 1996 to 0.062 kilogram in 2015. China and Indonesia, with the highest carbon emission per GDP among selected countries, had carbon gap of 90% and 95% respectively. In Nigeria, no evident of functional carbon tax is identified despite ongoing debates, which suggests that environmental costs of production activities may still be higher in Nigeria than those of the trading partners.

As revealed in Table 2.5, carbon emission per capita seems to exhibit direct relationship with cost of business start-up. For instance, United Kingdom, France, Norway and Sweden, which are among the selected countries with low carbon emission per GDP, have business start-up cost below 2% of gross national income (GNI) for most of the period 2003-2018. These countries also ranked 32 and below on the ease of doing business scale (Figure 2.4) and are among the countries with low carbon pricing gap. This suggests that being environmentally efficient may triggered improved business environment by reducing cost of production of goods both to the firm and to the society. Conversely, Indonesia and India, which recorded slightly high carbon emission per GDP, have relatively higher cost of business start-up and raked lowest among Nigeria's trading partners on the ease of doing business scale. These countries also have carbon pricing gap of 95% and 86% respectively, which indicate that firms pay low carbon taxes relative to the benchmark, contributing to the low environmental efficiency that may increase associated cost where government pay less attention to business environment.

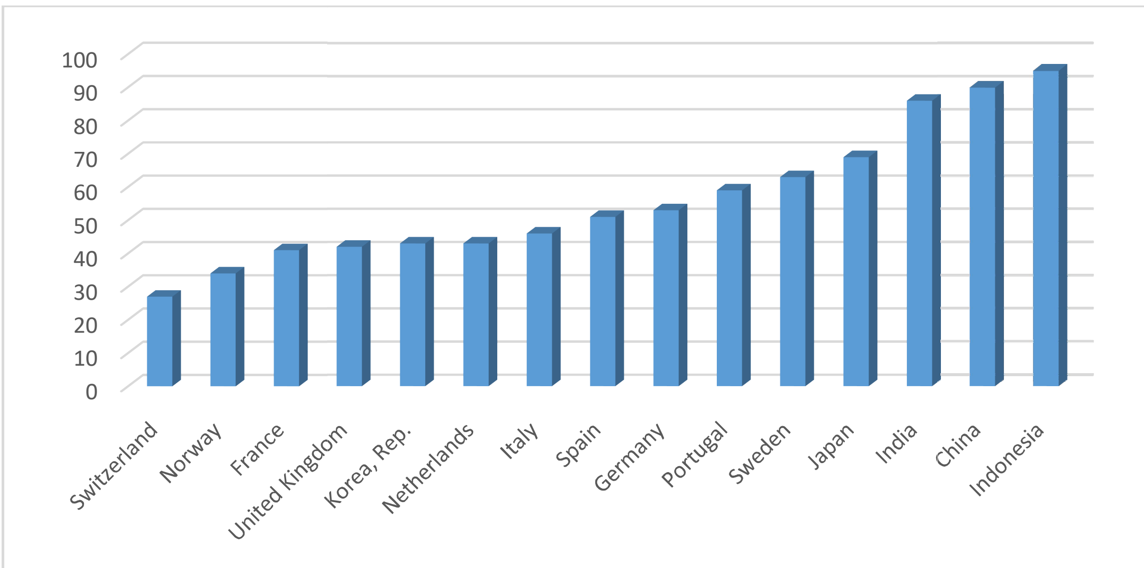

Figure 2.4. Carbon Pricing Gap
Source: Author's Computation based on data from OECD, 2018

Table 2.4.Cost of business start-up procedures (% of GNI per capita)

Country	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Switzerland	8.9	8.9	9	2.5	2.4	2.4	2.3	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3
China	-	-	-	-	-	-	-	-	-	-	1.9	0.9	0.7	0.7	0.6	0.4
Germany	6.1	6.1	4.9	5.3	5.8	5.8	4.9	5	4.8	5	5	8.9	7	6.8	7	6.7
Spain	16.8	17	16.5	16.2	15.1	14.9	15	15.1	4.7	5	5	4.5	4.4	4.3	4.1	4
France	1.4	1.1	1.2	1.1	1.1	1	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.7	0.7	0.7
United Kingdom	1	0.9	0.7	0.7	0.8	0.8	0.7	0.7	0.7	0.7	0.3	0.3	0.1	0.1	0	0
Hong Kong	2.4	3.4	3.4	3.3	3.1	2	1.8	2	1.9	1.9	0.8	1.4	1.2	0.6	1.1	1.1
Indonesia	-	-	-	-	-	-	-	-	-	-	21.9	21.1	19.9	19.4	10.9	6.1
India	-	-	-	-	-	-	-	-	-	-	41.5	16.4	14.5	14	15	14.4
Italy	22.1	21.4	20.7	20	18.7	18.5	18	18.7	18.4	16.7	14.7	14.8	14.4	14.3	14.1	14.1
Japan	-	-	-	-	-	-	-	-	-	-	7.5	7.5	7.5	7.5	7.5	7.5
Korea, Rep.	18.4	15.7	15.7	18.2	17.1	16.9	14.7	14.7	14.6	14.6	14.6	14.5	14.5	14.6	14.6	14.6
Nigeria	-	-	-	-	-	-	-	-	-	-	58.7	33.4	31.2	31.3	29.2	27.6
Netherlands	13.3	13.2	13	7.2	6	5.9	5.6	5.7	5.5	5.1	5.2	5	4.6	4.5	4.4	4.2
Norway	3.5	2.9	2.7	2.5	2.3	2.1	1.9	1.8	1.8	1.7	1.6	0.9	0.9	0.9	0.9	0.9
Portugal	12	13.5	13.4	7.9	6.7	6.5	6.4	6.5	2.3	2.3	2.4	2.3	2.2	2.1	2.1	2
Singapore	1	1	0.9	0.8	0.8	0.9	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.5	0.4
Sweden	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5

Source: Author's Computation; Data from World Bank WDI (2017)

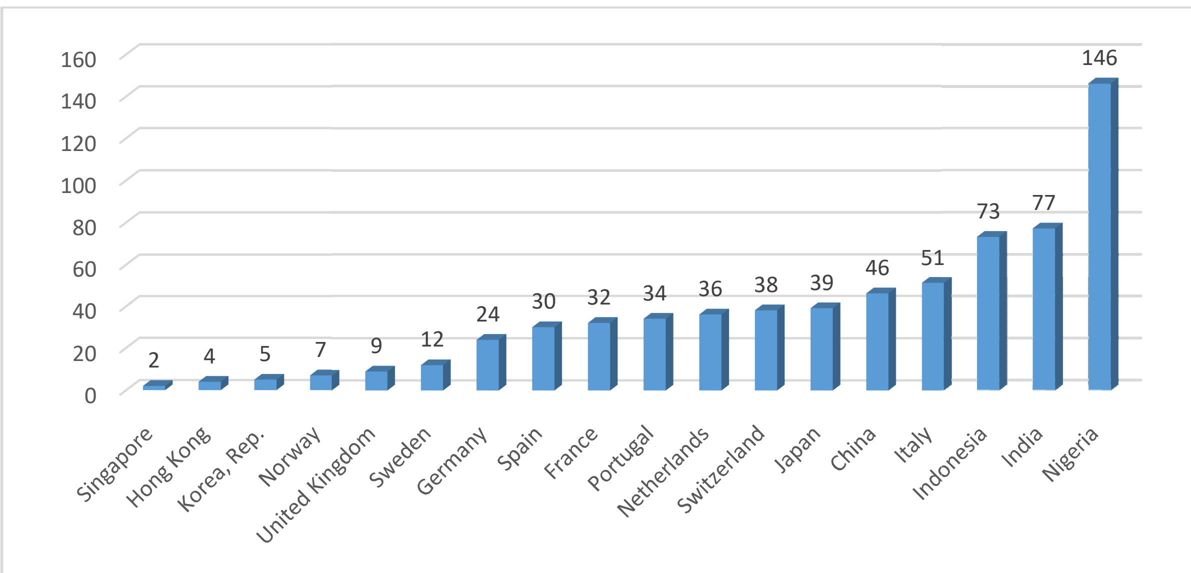

Figure 2.5. Ease of doing business index: 2018 (1=most business-friendly regulations)
Source: Author's Computation; Data from World Bank WDI (2017)

Countries such as China has low cost of business start-up, ranked 46 on the ease of doing business scale but recorded high carbon emission per dollar of output while having 90% carbon pricing gap. This may reflect government incentives and commitment to improving business environment that reduces production cost despite firms not accounting for the environmental impact of their activities relative to other countries. For Nigeria, given the relatively high carbon emission per GDP, cost of business start-up is highest compared to her top trading partners in the EU+2 and Asia while ranking 146 on the ease of doing business scale. This may corroborate the high cost associated with poor business environment that reflects less responsibility of firms to the society and government in terms of accounting environmental impact of production process.

2.2.6 Share of Top Partners in Nigeria's World and Regional Trade

The EU+2 and Asia remain among the major trading partners of Nigeria over the period 1996-2014. Over this period, the combined share of Nigeria's top Asian partners in her total export grew by about 17 percentage points to a peak of 25% in 2014 (Tables2.5a), although this remarkable growth was interrupted at different times.The growth performance could be attached to the recent wave of industrialisation in some Asian economies that require increase use of energy (oil) that is mainly source from Nigeria.It is also observed that India is a major destination of Nigerian export having risen significantly from a share of about 1.26% of Nigeria's total export in 1996 to about a record 14.56% in 2014. Except in recent years, the share of most of the other partners in Asia hardly rose above 1%. In terms of total import of Nigeria, the combine share of top

Asian partners rose steadily from about 15% in 1996 to 35% in 2014, an indication of increased importance of the Nigerian market for Asian export.

The top ten economies in the EU+2 maintained a combine share of about 40% in total export of Nigeria for almost two decades (1996-2014), after recovering gradually from a share of about 20% in 2006. This share was about four-fold higher than that of the combined share of the top (seven) Nigerian partners in Asia in 1996, although it was reduced to about 15 percentage points in 2014. This suggests that despite the increased importance of the Asian market to Nigeria's export activities, the EU+2 still provides greater market avenues for Nigerian products. Spain alone received about 12% of Nigeria's total export to the world in 1996 while France boasts of about 9% in the same year. These countries remain dominant until the emergence of the Netherlands as a major destination for export of Nigeria with a share of over 10% of total export to the world in 2013 and 2014. It readily becomes obvious from Table 2 that, unlike the case of Asia, export of Nigeria to the EU+2 is not concentrated in one country as these countries have their fair share of total export of Nigerian.

In terms of total import, it appears that Asia has gradually taken over the Nigerian market from the EU+2. The combine contribution of top Asian partners to total import of Nigeria rose significantly from about 15% in 1996 to about 36% in 2014 while the EU+2 witnessed a noticeable decline in their share of Nigerian market from almost 50% in 1996 to about 23% in 2014 (Tables 2.5b). This may reflect the recent appetite of Nigerians for cheap and substandard varieties, mostly manufactures, from China, and an indication of weak policy and regulation (including environmental regulation) in Nigeria. In fact, by 2012, the share of China (22%) alone in total import of Nigeria is higher than that recorded by all the top ten partners combined (18%) while they remain at par (about 22%) in 2013 and 2014. India and Japan also contributed significantly to Nigeria's total import. Nigeria's declining patronage of the EU+2 commodities is evident in falling share of the individual countries in the total import of Nigeria over the period 1996-2014. For instance, with the exception of Netherlands, who maintain its share of about 6% over the same period, all the top EU partners recorded major decline in the share of Nigerian market.

Table 2.5a. Share of Nigeria's Top Partners in Total Export of Nigeria (%)

Region	Country	1996	2001	2006	2011	2012	2013	2014
Asia	China	0.073	0.704	0.007	2.011	5.616	1.226	1.623
	India	1.356	11.544	9.301	10.180	11.104	12.648	14.562
	Japan	1.299	0.958	1.880	0.308	0.489	0.499	3.167
	Singapore	0.743	-	0.012	0.254	1.041	0.735	0.408
	HongKong	0.021	0.001	0.011	0.169	0.059	0.179	0.133
	Indonesia	0.534	2.977	0.001	0.745	1.054	2.331	3.919
	Korea Rep	4.083	0.275	3.551	0.056	0.033	0.033	0.906
	Total Share	**8.108**	**16.460**	**14.762**	**13.723**	**19.395**	**17.652**	**24.718**
EU+2	Netherlands	6.600	2.021	2.581	2.129	6.956	10.513	10.199
	Spain	11.674	6.514	7.981	5.900	5.450	6.985	9.310
	Italy	6.837	4.732	2.480	5.098	6.145	6.977	4.378
	Portugal	2.852	2.557	1.234	1.546	0.760	0.963	1.715
	UK	1.450	0.248	0.054	6.215	6.316	5.139	5.060
	France	8.638	6.330	5.659	5.866	4.163	5.868	5.733
	Germany	0.703	1.350	0.006	1.015	1.498	2.285	1.690
	Switzerland	0.027	0.004	0.017	0.405	0.051	0.095	0.005
	Norway	0.001	0.001	0.024	0.196	0.168	0.414	0.142
	Sweden	0.673	0.327	0.001	0.002	0.673	1.398	1.446
	Total Share	**39.455**	**24.084**	**20.037**	**28.372**	**32.179**	**40.638**	**39.677**

Source: Author's Computation; Data from World Integrated Trade Solution (WITS)

Table 2.5b. Share of Nigeria's Top Partners in Total Import of Nigeria (%)

Region	Country	1996	2001	2006	2011	2012	2013	2014
Asia	China	3.471	6.620	13.802	14.769	21.508	21.704	21.924
	India	2.579	3.967	4.845	3.861	8.050	4.730	5.962
	Japan	4.967	4.527	3.306	4.520	2.735	1.346	1.716
	Singapore	0.858	1.303	1.570	1.235	1.109	0.796	0.510
	HongKong	1.889	1.211	1.153	0.718	0.372	0.359	0.386
	Indonesia	0.907	1.355	0.480	0.000	0.078	0.855	1.430
	Korea Rep	0.988	2.716	2.667	1.044	1.550	2.970	3.720
	Total Share	**15.659**	**21.699**	**27.825**	**26.147**	**35.402**	**32.760**	**35.648**
Europe	Netherlands	6.066	4.922	3.084	2.364	1.446	5.421	6.108
	Spain	1.774	1.360	0.831	1.528	0.852	2.134	1.656
	Italy	3.540	2.523	3.411	2.814	2.084	1.724	2.211
	Portugal	0.209	0.115	0.056	0.184	0.101	0.144	0.101
	UK	13.078	13.442	11.793	2.655	6.581	5.243	3.923
	France	8.246	4.671	4.493	4.491	2.054	2.791	2.508
	Germany	10.544	9.811	5.580	4.710	2.660	3.463	3.831
	Switzerland	1.461	1.213	0.942	0.417	0.836	0.317	0.617
	Norway	0.707	0.243	0.212	0.605	0.595	1.099	1.344
	Sweden	1.192	0.661	0.491	0.541	1.225	0.586	0.582
	Total Share	**46.817**	**38.961**	**30.892**	**20.310**	**18.434**	**22.922**	**22.879**

Source: Author's Computation; Data from World Integrated Trade Solution (WITS)

Within Asia, India remains the largest market for Nigerian export after an initial dominance of Korea Republic in prior to 2001 (Table 2.6a). Beginning from 2001, India has consistently remained Nigerian biggest market in Asia with a share as high as 34% and 40% of the Nigeria's total export to Asia in 2001 and 2008 respectively, having reached a recent minimum of about 25% in 2012. Singapore and Hong Kong are among the Asian countries with the least share of Nigerian export to the region. The top seven Nigerian trading partners in Asia command a combine share of Nigerian market in Asia that ranges between 40% and 50% for most part of 1996-2014. Elsewhere, the combine share of the top ten partners in the EU+2stood above 90% throughout the period 1996-2014. Within the EU+2, Spain and France represented the leading market for Nigerian exports prior to 2012, commanding a share of 38% and 27% of total export to the EU+2 in 2006. However, they lost their dominance to the Netherlands whose share in Nigerian export rose from 8% in 2001 to 25% in 2014 to stand as the largest market for Nigerian goods and services with the EU+2. This could suggest the increased economic relationship between Nigeria and the Netherlands in the recent years as the latter is a major aid to trade donor benefitted by the former.Switzerland, Norway and Sweden remain the least market for Nigerian export to the EU+2.

In terms of Nigerian import from Asia, the top seven leading partners maintained a contribution that hovered between 43% and 47% throughout the 1996-2014 period (Table 2.6b). However, the contributions across partners vary over the same period as some countries experience tremendous jump in their share of the Asian market in Nigeria while others either maintained their share or found it declining. In particular, the market share of China rose remarkably by almost 20 percentage point during the same period, to settle at about 31% and 29% in 2013 and 2014 respectively. In contrast, while the share of India in total export of Asia to Nigeria remained at about 7% between 1996 and 2014 after hitting a peak of 10% in 2012, that of Japan (and Hong Kong) dropped sharply from 14% (5%) in 1996 to 2% (0.5%) in 2014. This simply indicates that Nigeria has successfully shifted its import attention away from other Asian partners towards China whose relevance to the Nigerian economy is increasingly recognised. The combine share of the top EU+2 partners in Nigeria's total import from the EU+2 declined during 1996-2014, although this share remained very high (above 68%) when compared with Asian top partners' contribution to total export of Asia to Nigeria. Specifically, Italy, The United Kingdom, France and Germany witnessed major drop in their share of Nigerian market while Spain and Norway only recorded marginal increase in their share with share of the Netherlands rising the most, having moved from 12% in 1996 to 18% in 2014.

Table 2.6a. Share of Nigeria's Top Partners in Export to Asia and the EU+2 (%)

Region	Country	1996	2001	2006	2011	2012	2013	2014
Asia	China	0.446	2.107	0.024	5.634	12.467	2.898	2.981
	India	8.326	34.553	31.498	28.514	24.651	29.894	26.746
	Japan	7.979	2.869	6.366	0.862	1.085	1.179	5.817
	Singapore	4.562	0.000	0.041	0.713	2.312	1.737	0.749
	HongKong	0.129	0.001	0.036	0.474	0.131	0.424	0.245
	Indonesia	3.281	8.910	0.001	2.087	2.339	5.509	7.198
	Korea Rep	25.072	0.824	12.027	0.156	0.074	0.079	1.664
	Total Share	**49.793**	**49.264**	**49.993**	**38.439**	**43.058**	**41.720**	**45.400**
Europe	Netherlands	16.128	8.390	12.218	7.477	19.547	24.950	24.884
	Spain	28.526	27.051	37.778	20.719	15.315	16.578	22.716
	Italy	16.708	19.653	11.738	17.902	17.268	16.558	10.681
	Portugal	6.969	10.618	5.840	5.429	2.134	2.285	4.185
	UK	3.543	1.032	0.255	21.827	17.749	12.195	12.344
	France	21.108	26.117	26.789	20.602	11.697	13.925	13.987
	Germany	1.719	5.601	0.028	3.565	4.209	5.423	4.122
	Switzerland	0.066	0.015	0.082	1.421	0.143	0.226	0.012
	Norway	0.001	0.002	0.115	0.687	0.472	0.983	0.346
	Sweden	1.643	1.359	0.000	0.008	1.891	3.318	3.527
	Total Share	**96.412**	**99.837**	**94.843**	**99.638**	**90.425**	**96.442**	**96.804**

Source: Author's Computation; Data from World Integrated Trade Solution (WITS)

Table 2.6b. Share of Nigeria's Top Partners in Import from Asia and the EU+2 (%)

Region	Country	1996	2001	2006	2011	2012	2013	2014
Asia	China	9.699	13.825	21.761	25.567	27.635	30.944	27.821
	India	7.206	8.285	7.640	6.685	10.343	6.744	7.566
	Japan	13.879	9.454	5.213	7.825	3.514	1.919	2.178
	Singapore	2.397	2.722	2.476	2.138	1.426	1.134	0.647
	Hong Kong	5.277	2.530	1.818	1.244	0.478	0.512	0.490
	Indonesia	2.536	2.829	0.757	0.000	0.101	1.219	1.814
	Korea Rep	2.761	5.672	4.206	1.807	1.991	4.235	4.720
	Total Share	**43.755**	**45.317**	**43.871**	**45.266**	**45.488**	**46.707**	**45.237**
Europe	Netherlands	12.162	10.834	8.307	9.668	6.207	17.434	18.248
	Spain	3.556	2.995	2.238	6.250	3.658	6.862	4.946
	Italy	7.096	5.553	9.187	11.509	8.949	5.545	6.604
	Portugal	0.419	0.254	0.152	0.754	0.434	0.462	0.300
	UK	26.221	29.589	31.765	10.860	28.254	16.861	11.720
	France	16.532	10.281	12.101	18.368	8.820	8.975	7.493
	Germany	21.140	21.595	15.030	19.264	11.420	11.137	11.445
	Switzerland	2.929	2.671	2.536	1.705	3.589	1.019	1.842
	Norway	1.416	0.535	0.571	2.473	2.554	3.535	4.014
	Sweden	2.390	1.455	1.322	2.213	5.261	1.885	1.739
	Total Share	**93.861**	**85.761**	**83.210**	**83.065**	**79.147**	**73.714**	**68.351**

Source: Author's Computation; Data from World Integrated Trade Solution (WITS)

2.2.7Structure of Nigeria's Trade with Asia and the EU+2

In real terms, total export volume of Nigeria to Asia and the EU+2followed an increasing trend since the 1990s. Analysis of the structure of export of the country shows a consistent bias towards mineral export as it comprised over 90% of the total export for most of 1996-2014. As revealed in Figure 2.6, mineral export to economies both in Asia and the EU+2 continued to rise over the period 1996-2014, with major shock experienced in 2013. It is also observed that Nigeria exported more mineral products to the EU+2 than Asia over the same period. For instance, while real mineral export to the EU+2 rose from $90.36 million in 2001 to a peak of about $198.51 million in 2014 (representing 120% growth), real export of the product to Asia rose gradually and persistently from $22.39 in 1996 to about $121.76 (444% growth) million and $137.23 (513% growth) million in 2012 and 2014 respectively after a major shock in 2013.This indicates the continuous rise in the demand for energy, especially high quality crude oil, in the developed nations of Europe, as well as the emerging Asian nations, for industrial purposes for which Nigeria is a major producer.

Generally, non-mineral export of Nigeria to top partners in Asia and the EU+2 appears to be higher over the period 2011-2014 that those recorded between 1996 and 2006. As shown in Figure 2.7, real non-mineral export of Nigeria to Asian partners rose remarkably from about $201,051 in 1996 and $2,329 in 2001, to reach an apex of about $23.40

million in 2012 before falling to a recent minimum of about $6.60 million in 2014. For the top EU+2 trading partners, real non-mineral import from Nigeria increase outstandingly from $87,561 in 2001 to 52.79 million in 2012before settling at about $34.39 million in 2014. This implies that the demand for non-mineral product of Nigeria among its partners is rising in recent years, especially within the EU+2 as most of their raw materials are sought from developing countries including Nigeria.

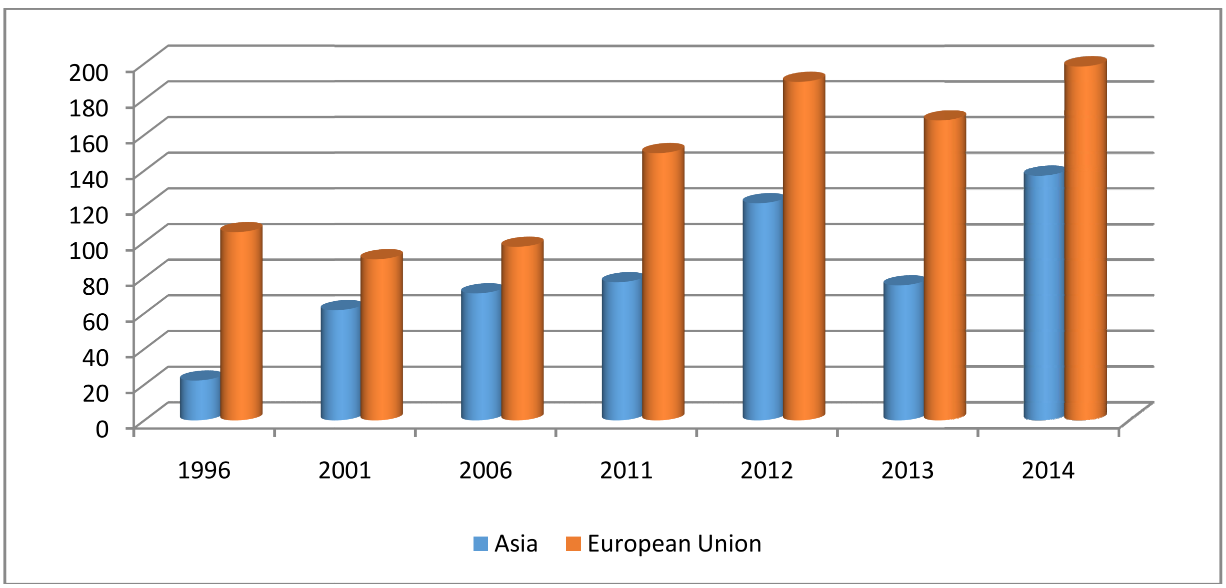

Figure 2.6. Nigeria's Mineral Export to Asia and the EU+2 (Million US$: 2005=100)
Source: Author's Computation; Data from World Integrated Trade Solution (WITS)

Nigeria imports substantial volume of its mineral products from partners in the EU+2, with very small volume coming from those in Asia. Real mineral import of the country from EU+2 partners rose steadily from $1.38 million in 1996 to $6.09 million in 2011, accounting for about 341% increase, before reaching a peak of $17.88 million in 2014 (Figure 2.8). Real volume of mineral product import from top trading partners in Asia remain below $2.2 million throughout 1996-2014 period having recorded a maximum of about $2.12 million in 2011. Energy imports in Nigeria consist mainly of refined petroleum products such as gasoline, kerosene, diesel and liquefied natural gas, the production of which concentrateslargely in Europe. In essence, much of Nigeria's crude oil export to Europe is imported back in form of refined petroleum products.

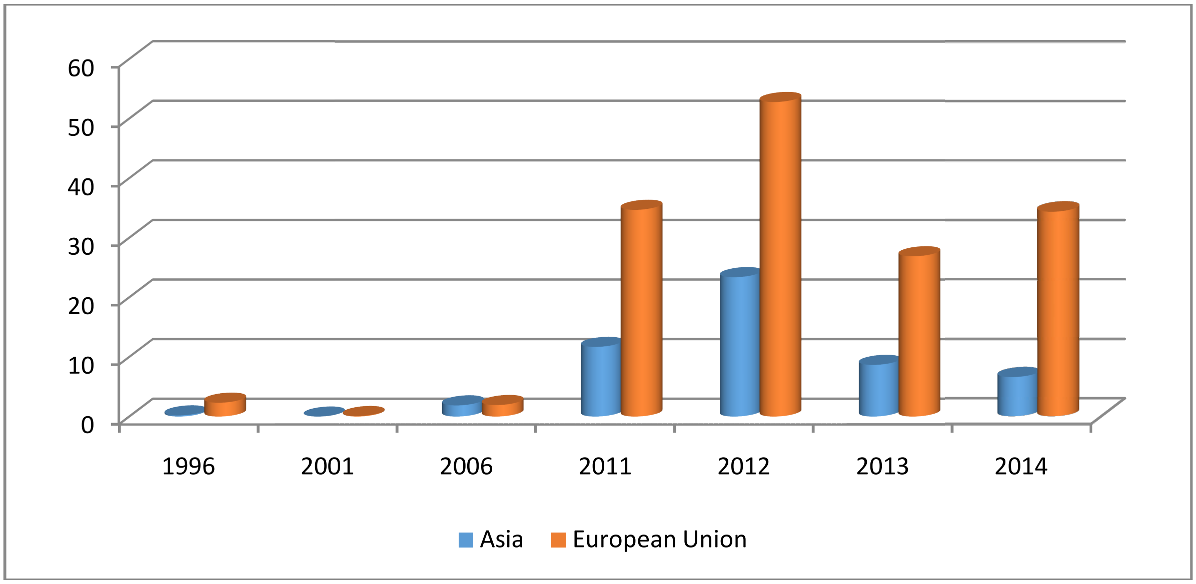

Figure 2.7. Nigeria's Non-mineral Export to Asia and the EU+2 (Million US$: 2005=100)
Source: Author's Computation; Data from World Integrated Trade Solution (WITS)

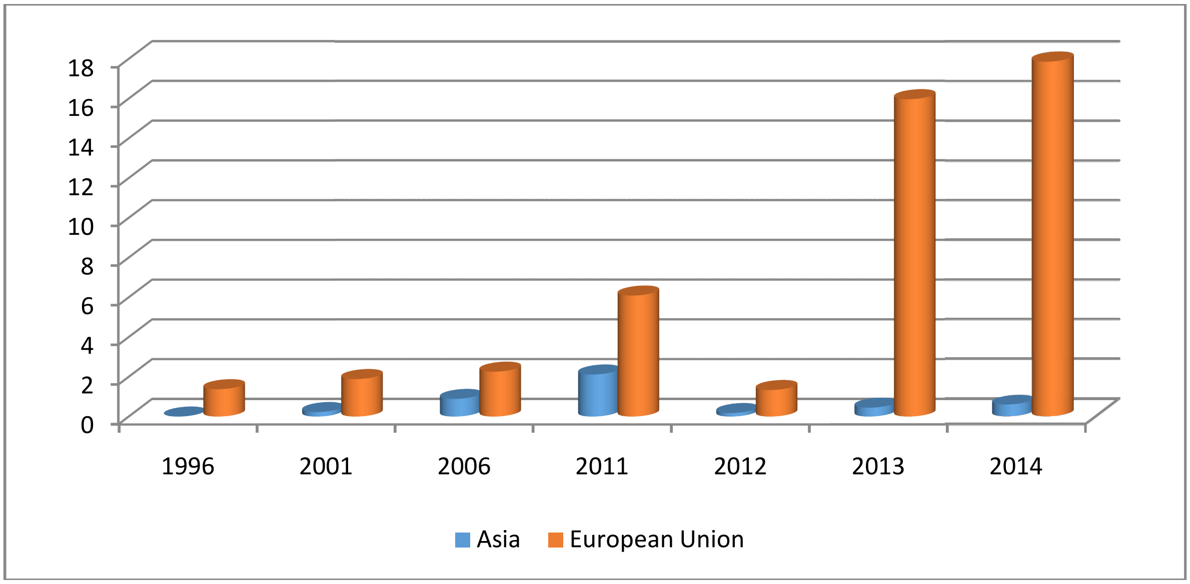

Figure 2.8. Nigeria's Mineral Import from Asia and the EU+2 (Million US$: 2005=100)
Source: Author's Computation; Data from World Integrated Trade Solution (WITS)

In terms of import, while Nigeria purchased reasonable volume of mineral products from top partners both in Asia and the EU+2, there appear to be a bias in favour of the EU+2 for mineral products.Between 1996 and 2006, the real volume of non-mineral products imported from the top partners in the EU+2 was consistently higher than those imported from partners in Asia (Figure 2.9). However, by 2011, real volume of non-mineral import from Asian partners has overtaken those from the EU+2. It is also observed that, although real import volume of this product from top partners in both regions followed upward trend between 2012 and 2014, the gap between them continues to increase. For instance, in 1996 real non-mineral import from partners in the EU+2 is greater than those from Asia by 192% which fell gradually to about 9% in 2006. In 2011, such import from Asia is greater than those from the EU+2 by about 38% which rose continuously to about 121% in 2014. This suggests that real import of non-mineral products such as consumer and industrial goods by Nigerians are increasingly sourced from Asia, perhaps they are relatively cheaper than those from other regions.

Analysis of Nigeria's trade balance shows that, in terms of real export of mineral products to top partners in Asia outweighs import of the product from these countries which yields positive trade balance in mineral products in favour of Nigeria during 1996-2014. However, in terms of non-mineral products, Nigeria appears indebted to Asian top partners combined as the country consistently imported more of the product from these partners than they exported to them during the same period. Similarly, real export of mineral products to partners in the EU+2 was greater than its import throughout the period 1996-2014, suggesting that these partners are indebted to Nigeria as far as mineral product is concerned. For non-mineral products, except in 2012, Nigeria trade balance with EU+2 partners was negative over the same period. Overall, analysis of trade structure of the Nigeria reveals that the country derives its strength in export of mineral product which indicates the area of comparative advantage of the country, being well abundantly endowed with oil resources.

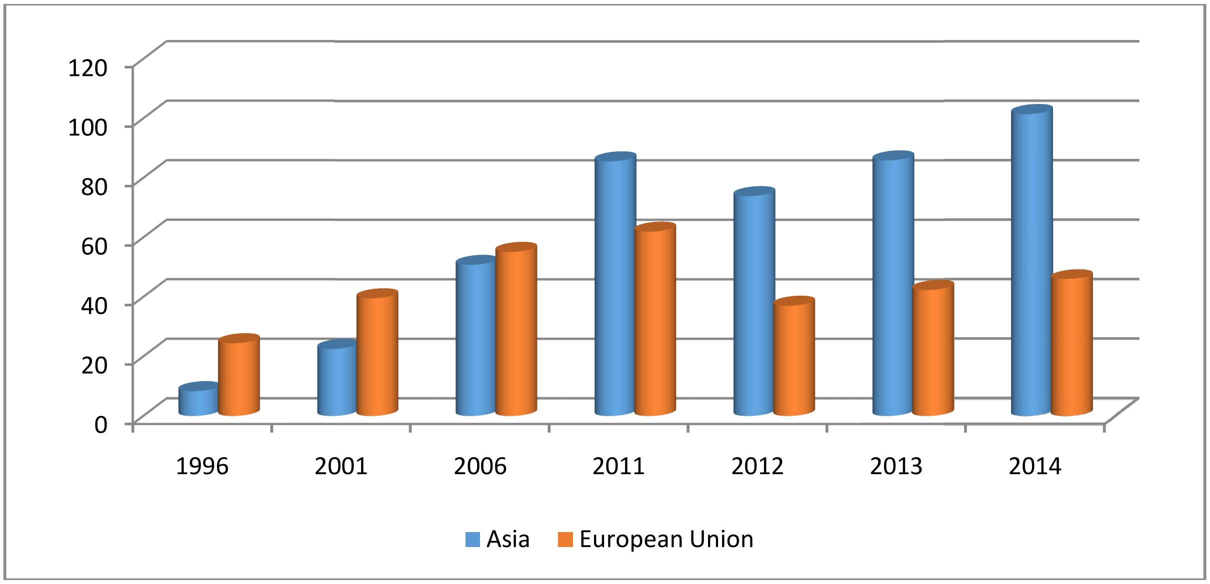

Figure 2.9. Nigeria's Non-mineral Import from Asia and the EU+2 (Million US$: 2005=100)
Source: Author's Computation; Data from World Integrated Trade Solution (WITS)

For the individual Asian top partners, Nigeria's export to these countries appears dominated by mineral products over the period 1996-2014, reaching up to 100% for some partners in some years (Table 2.7). For instance, all Nigerian exports to China, Japan, Korea Republic and Indonesia in 2001were all mineral products while this is also observed for the case of Japan in 2006 and Indonesia in 2011.In addition, Nigeria's real volume of mineral export to Hong Kong seems to be the least among partners in Asia while that of non-mineral export is lowest in the case of Indonesia for most of the period under consideration. For non-mineral products, China, Japan and India appear to be Nigeria's top destination as they consistently recorded the highest real volume of non-mineral product import from Nigeria among Asian top partners.

In terms of real imports, Nigeria imported more non-minerals products than mineral product from all the top partners in Asia for all the years between 1996 and 2014 as over 90% of the country's imports from these partners consisted of non-mineral products for most of the same period (Table 2.8). Such import, which was initially largest from Japan in 1996, became increasingly sourced from China between 2001 and 2014.

Table 2.7. Mineral and Non-Mineral Export of Nigeria to AsiaPartners ('000 $US: 2005 = 100)

Country	Product	1996	2001	2006	2011	2012	2013	2014
China	Mineral Export	-	2,644.54	-	5,871.53	32,850.96	4,480.15	85,09.88
	Non-mineral export	82.87	-	33.54	7,293.11	9,512.06	1,488.71	980.64
	Total	82.87	2,644.54	33.54	13,164.64	42,363.02	5,968.86	9,490.52
	Share of mineral export	-	100.00	-	44.60	77.55	75.06	89.67
Japan	Mineral Export	3,636.65	3,600.89	9,320.44	786.32	2,222.03	1,011.38	16,838.41
	Non-mineral export	12.34	-	0.19	1,230.69	1,553.35	1,527.15	1,661.32
	Total	3,649.00	3,600.89	9,320.63	2,017.01	3,775.38	2,538.53	18,499.73
	Share of mineral export	99.66	100.00	100.00	38.98	58.86	39.84	91.02
Hong Kong	Mineral Export	-	-	-	676.59	143.35	271.37	-
	Non-mineral export	24.00	0.09	50.89	426.93	331.68	653.43	843.78
	Total	24.00	0.09	50.89	1,103.52	475.03	924.81	843.78
	Share of mineral export	-	-	-	61.31	30.18	29.34	-
Singapore	Mineral Export	2,083.56	-	-	1,114.72	1,987.04	2,138.55	1,913.24
	Non-mineral export	5.29	-	58.69	544.11	6,440.20	1,512.39	492.83
	Total	2,088.85	-	58.69	1,658.83	8,427.23	3,650.94	2,406.07
	Share of mineral export	99.75	-	-	67.20	23.58	58.58	79.52
Korea Republic	Mineral Export	11,518.12	1,034.96	17,404.63	216.67	163.61	0.15	4,677.77
	Non-mineral export	1.88	-	196.90	146.60	91.57	179.08	628.15
	Total	11,520.00	1,034.96	17,601.52	363.28	255.18	179.24	5,305.92
	Share of mineral export	99.98	100.00	98.88	59.64	64.11	0.09	88.16
Indonesia	Mineral Export	1,476.07	11,184.24	-	4,829.99	7,695.36	10,537.05	22,611.85
	Non-mineral export	12.86	-	0.01	-	38.66	535.73	110.46
	Total	1,488.93	11,184.24	0.01	4,829.99	7,734.02	11,072.78	22,722.31
	Share of mineral export	99.14	100.00	-	100.00	99.50	95.16	99.51
India	Mineral Export	3,673.65	43,370.73	44,525.38	63,972.52	76,696.71	57,285.03	82,679.81
	Non-mineral export	61.81	2.24	1,540.27	2,058.91	5,432.04	2,783.62	1,880.86
	Total	3,735.45	43,372.97	46,065.65	66,031.43	82,128.75	60,068.65	84,560.67
	Share of mineral export	98.35	99.99	96.66	96.88	93.39	95.37	97.78
Total	Mineral Export	22,388.05	61,835.36	71,250.45	77,468.35	121,759.05	75,723.69	137,230.97
	Non-mineral export	201.05	2.33	1,880.48	11,700.34	23,399.55	8,680.12	6,598.03
	Total	22,589.10	61,837.69	73,130.93	89,168.70	145,158.60	84,403.81	143,829.00
	Share of mineral export	99.11	99.99	97.43	86.88	83.88	89.72	95.41

Source: Author's Computation; Data from World Integrated Trade Solution (WITS)

Table 2.8. Mineral and Non-Mineral Import of Nigeria from Asian Partners ('000 $US: 2005 = 100)

Country	Product	1996	2001	2006	2011	2012	2013	2014
China	Mineral Import	0.26	37.61	607.05	606.97	37.10	44.69	188.36
	Non-mineral Import	1,856.37	6,910.72	25,057.70	48,984.66	45,013.56	57,254.50	62,640.64
	Total	1,856.63	6,948.33	25,664.75	49,591.63	45,050.66	57,299.19	62,829.00
	Share of Non-mineral Import	99.99	99.46	97.63	98.78	99.92	99.92	99.70
Japan	Mineral Import	-	28.95	0.27	0.82	0.45	1.09	0.54
	Non-mineral Import	2,656.38	4,723.49	6,143.08	15,179.33	5,729.08	3,552.91	4,919.66
	Total	2,656.38	4,752.44	6,143.36	15,180.16	5,729.52	3,554.00	4,920.20
	Share of Non-mineral Import	100.00	99.39	100.00	99.99	99.99	99.97	99.99
Hong Kong	Mineral Import	0.51	-	7.48	2.23	0.92	1.27	1.73
	Non-mineral Import	1,009.89	1,268.95	2,135.33	2,410.37	778.48	946.30	1,105.95
	Total	1,010.40	1,268.95	2,142.82	2,412.59	779.40	947.57	1,107.68
	Share of Non-mineral Import	99.95	100.00	99.65	99.91	99.88	99.87	99.84
Singapore	Mineral Import	0.06	22.76	28.19	1.81	1.60	157.57	5.42
	Non-mineral Import	458.79	1,350.94	2,890.55	4,146.09	2,322.37	1,922.06	1,455.49
	Total	458.85	1,373.69	2,918.75	4,147.90	2,323.97	2,079.62	1,460.91
	Share of Non-mineral Import	99.99	98.34	99.03	99.96	99.93	92.42	99.63
Korea Rep	Mineral Import	0.57	116.75	6.27	1.94	0.44	1.42	0.60
	Non-mineral Import	528.15	2,771.11	4,950.42	3,504.26	3,246.02	7,840.79	10,661.37
	Total	528.71	2,887.86	4,956.69	3,506.20	3,246.46	7,842.21	10,661.96
	Share of Non-mineral Import	99.89	95.96	99.87	99.94	99.99	99.98	99.99
Indonesia	Mineral Import	-	21.55	22.01	-	-	2.00	1.46
	Non-mineral Import	485.29	1,405.35	871.37	-	164.42	2,255.24	4,096.46
	Total	485.29	1,426.90	893.38	-	164.42	2,257.24	4,097.92
	Share of Non-mineral Import	100.00	98.49	97.54	-	100.00	99.91	99.96
India	Mineral Import	1.18	4.87	216.10	1,502.43	142.57	243.96	387.54
	Non-mineral Import	1,378.72	4,152.33	8,793.92	11,440.04	16,700.68	12,212.28	16,666.66
	Total	1,379.90	4,157.20	9,010.02	12,942.48	16,843.24	12,456.23	17,054.20
	Share of Non-mineral Import	99.91	99.88	97.60	88.39	99.15	98.04	97.73
Total	Mineral Import	2.58	232.49	887.37	2,116.20	183.08	451.99	585.65
	Non-mineral Import	8,373.59	22,582.89	50,842.39	85,664.76	73,954.59	85,984.07	101,546.22
	Total	8,376.17	22,815.39	51,729.76	87,780.95	74,137.67	86,436.06	102,131.87
	Share of Non-mineral Import	99.97	98.98	98.28	97.59	99.75	99.48	99.43

Source: Author's Computation; Data from World Integrated Trade Solution (WITS)

By 2014, Nigeria's real import of non-mineral products from China was almost four times those from India, the second largest country of origin for Nigeria's imports in that year. It is also observed that Hong Kong is the least patronized by Nigeria as far as non-mineral products are concerned whose largest recorded export to Nigeria was \$2.41 million in 2011 behind Korea Republic who recorded real export volume of about \$3.50 million to Nigeria in the same year. It is therefore clear that while Nigeria recorded a surplus in its trade balance against each of the Asia top partners in terms of mineral products during 1996-2014, trade in non-mineral products with these partners experienced deficit over the same period. This suggests that while these economies are indebted to Nigeria in mineral products, the country is indebted to them in terms of non-mineral products.

Nigerian market for mineral product appears larger than that of non-mineral products among partners in the EU+2as top partners in the region consistently imported higher volume of mineral products than non-mineral products from Nigeria (Table 2.9).As at 2014, real volume of mineral export to the Netherlands (\$53.95 million) was the largest among top partners in the EU+2 followed by Spain (\$49.43 million), France (\$32.90 million) and Italy (\$20.02 million) in that order, while Norway (\$662,940)represented the least market for Nigeria's mineral product. For non-mineral products, the United Kingdom, Italy, the Netherlands, Spain and France in that order seems to be the largest markets for Nigeria's non-mineral products in recent years with real export volume of \$12.66 million, \$5.86 million, \$5.64 million, \$4.95 million respectively in 2014.

Similar to the case of Nigeria's top partners in Asia, Nigeria imported more non-mineral products from each of its EU+2 partners than mineral products for during 1996-2014, except for the Netherlands (2013 and 2014) and Spain (2013) from where Nigeria imported more mineral than non-mineral products for one or two years (Table 2.10).

Table 2.9.Mineral and Non-Mineral Export of Nigeria to the EU+2 Partners (‘000 $US: 2005 = 100)

Country	Product	1996	2001	2006	2011	2012	2013	2014
Netherlands	Mineral Export	17,319.79	7,577.59	12,727.90	13,396.40	47,741.21	41,047.70	53,953.60
	Non-mineral export	529.29	10.92	67.27	413.75	3,750.90	9,770.33	5,642.01
	Total	17,849.07	7,588.52	12,795.16	13,810.15	51,492.11	50,818.04	59,595.62
	Share of mineral export	97.03	99.86	99.47	97.00	92.72	80.77	90.53
Spain	Mineral Export	32,678.22	24,443.37	39,509.82	32,161.39	36,135.97	30,558.67	49,431.80
	Non-mineral export	109.36	20.13	57.94	6,194.28	4,386.40	2,761.91	4,954.97
	Total	32,787.58	24,463.50	39,567.77	38,355.67	40,522.37	33,320.58	54,386.77
	Share of mineral export	99.67	99.92	99.85	83.85	89.18	91.71	90.89
UK	Mineral Export	1,232.01	879.26	-	23,358.72	27,603.39	21,404.65	17,744.50
	Non-mineral export	1,157.64	34.33	259.16	17,231.82	21,350.36	3,252.84	12,663.03
	Total	2,389.65	913.60	259.16	40,590.54	48,953.74	24,657.49	30,407.53
	Share of mineral export	51.56	96.24	-	57.55	56.39	86.81	58.36
France	Mineral Export	24,216.96	23,778.23	27,253.66	33,278.90	22,824.19	24,743.21	31,900.45
	Non-mineral export	66.06	3.17	780.90	4,835.93	8,790.29	3,371.36	1,450.22
	Total	24,283.02	23,781.40	28,034.56	38,114.83	31,614.48	28,114.57	33,350.67
	Share of mineral export	99.73	99.99	97.21	87.31	72.20	88.01	95.65
Italy	Mineral Export	1,8915.22	17,775.67	11,734.08	29,256.23	37,095.87	29,720.84	20,016.83
	Non-mineral export	154.75	3.23	543.21	3,858.66	9,102.10	3,668.12	5,857.42
	Total	19,069.97	17,778.90	12,277.29	33,114.89	46,197.97	33,388.96	25,874.25
	Share of mineral export	99.19	99.98	95.58	88.35	80.30	89.01	77.36
Germany	Mineral Export	1,508.31	5,064.71	-	5,195.91	7,445.61	7,830.05	8,947.44
	Non-mineral export	192.99	4.05	28.84	1,408.84	4,037.41	3,363.88	924.03
	Total	1,701.30	5,068.77	28.84	6,604.75	11,483.02	11,193.93	9,871.47
	Share of mineral export	88.66	99.92	-	78.67	64.84	69.95	90.64
Portugal	Mineral Export	7,843.82	9,603.92	6,116.80	9,426.38	4,820.98	4,120.29	7,481.51
	Non-mineral export	83.35	1.98	0.18	606.95	856.62	485.06	2,689.35
	Total	7,927.17	9,605.90	6,116.99	10,033.32	5,677.60	4,605.35	10,170.85
	Share of mineral export	98.95	99.98	100.00	93.95	84.91	89.47	73.56
Norway	Mineral Export	-	-	-	1,159.89	1,014.95	1,889.79	662.94
	Non-mineral export	0.69	1.33	116.58	111.04	247.03	76.49	173.59
	Total	0.69	1.33	116.58	1,270.93	1,261.98	1,966.28	836.52
	Share of mineral export	-	-	-	91.26	80.43	96.11	79.25
Sweden	Mineral Export	1,885.54	1,229.72	-	14.07	4,870.01	6,569.48	8,374.09
	Non-mineral export	5.10	-	0.06	1.18	75.31	39.50	6.07
	Total	1,890.64	1,229.72	0.06	15.25	4,945.33	6,608.98	8,380.16
	Share of mineral export	99.73	100.00	-	92.29	98.48	99.40	99.93
Switzerland	Mineral Export	-	-	-	2,584.86	207.22	348.73	-
	Non-mineral export	30.68	8.42	83.20	38.75	189.98	113.62	30.16
	Total	30.68	8.42	83.20	2,623.61	397.20	462.35	30.16
	Share of mineral export	-	-	-	98.52	52.17	75.43	-
Total	Mineral Export	105,599.88	90,352.48	97,342.26	149,832.74	189,759.41	168,233.42	198,513.16
	Non-mineral export	2,329.90	87.56	1937.34	34,701.20	52,786.39	26,903.11	34,390.83
	Total	107,929.78	90,440.04	99,279.60	184,533.94	242,545.81	195,136.53	232,904.00
	Share of mineral export	97.84	99.90	98.05	81.20	78.24	86.21	85.23

Source: Author’s Computation; Data from World Integrated Trade Solution (WITS)

Table 2.10.Mineral and Non-Mineral Import of Nigeria from the EU+2 Partners ('000 $US: 2005 = 100)

Country	Product	1996	2001	2006	2011	2012	2013	2014
Netherlands	Mineral Import	170.93	77.16	617.94	68.78	41.28	7,235.30	8,989.84
	Non-mineral Import	3,175.20	5,107.19	5,132.14	7,870.01	2,981.25	6,100.58	7,678.64
	Total	3,346.13	5,184.35	5,750.08	7,938.79	3,022.53	13,335.88	16,668.49
	Share of Non-mineral Import	94.89	98.51	89.25	99.13	98.63	45.75	46.07
Spain	Mineral Import	147.43	57.47	123.01	1,706.01	158.66	3,075.60	1,931.08
	Non-mineral Import	888.88	1,388.73	1,424.83	3,396.77	1,604.11	2,142.78	2,634.34
	Total	1,036.31	1,446.21	1,547.84	5102.78	1,762.77	5,218.37	4,565.43
	Share of Non-mineral Import	85.77	96.03	,92.05	66.57	91.00	41.06	57.70
UK	Mineral Import	125.92	525.61	346.16	264.60	49.99	861.66	1,067.23
	Non-mineral Import	6,943.78	13,748.50	21,577.33	8,648.93	13,728.82	12,865.03	10,078.39
	Total	7,069.70	14,274.11	21,923.48	8,913.54	13,778.81	13,726.69	11,145.62
	Share of Non-mineral Import	98.22	96.32	98.42	97.03	99.64	93.72	90.42
France	Mineral Import	355.69	194.03	314.08	809.08	336.49	2,168.08	2,347.40
	Non-mineral Import	4,266.22	4,770.02	8,043.56	14,261.37	3,920.27	4,907.29	4,623.23
	Total	4,621.91	4,964.06	8,357.64	15,070.45	4,256.76	7,075.37	6,970.63
	Share of Non-mineral Import	92.30	96.09	96.24	94.63	92.10	69.36	66.32
Italy	Mineral Import	106.72	54.92	410.11	877.12	357.38	329.15	690.60
	Non-mineral Import	1,849.90	2,607.76	5,940.53	8,559.46	3,959.26	4,179.09	5,581.36
	Total	1,956.61	2,662.68	6,350.63	9,436.58	4,316.64	4,508.23	6,271.96
	Share of Non-mineral Import	94.55	97.94	93.54	90.71	91.72	92.70	88.99
Germany	Mineral Import	418.16	618.79	277.25	2,058.40	117.04	142.75	192.51
	Non-mineral Import	5,470.15	9,885.78	10,099.70	13,725.89	5,438.85	8,981.77	10,770.61
	Total	5,888.31	10,504.57	10,376.95	15,784.29	5,555.89	9,124.53	10,963.12
	Share of Non-mineral Import	92.90	94.11	97.33	86.96	97.89	98.44	98.24
Portugal	Mineral Import	45.45	58.51	-	26.06	16.30	10.84	-
	Non-mineral Import	93.33	83.79	104.54	592.38	193.02	366.90	288.13
	Total	138.78	142.30	104.54	618.44	209.32	377.74	288.13
	Share of Non-mineral Import	67.25	58.88	100.00	95.79	92.21	97.13	100.00
Norway	Mineral Import	-	-	-	0.36	-	1,951.84	2,470.30
	Non-mineral Import	377.86	254.79	394.08	2,030.52	1,246.09	687.09	1,150.43
	Total	377.86	254.79	394.08	2,030.88	1,246.09	2,638.93	3,620.73
	Share of Non-mineral Import	100.00	100.00	100.00	99.98	100.00	26.04	31.77
Sweden	Mineral Import	-	40.81	0.64	0.44	50.93	159.47	0.87
	Non-mineral Import	637.68	666.38	911.50	1,817.10	2,509.09	1,366.43	1,667.26
	Total	637.68	707.19	912.14	1,817.54	2,560.02	1,525.90	1,668.13
	Share of Non-mineral Import	100.00	94.23	99.93	99.98	98.01	89.55	99.95
Switzerland	Mineral Import	8.38	267.26	168.29	280.64	207.44	33.64	195.07
	Non-mineral Import	778.02	1,101.91	1,586.60	1,114.68	1,514.82	798.43	1,554.07
	Total	786.41	1,369.17	1,754.89	1,395.31	1,722.27	832.07	1,749.15
	Share of Non-mineral Import	98.93	80.48	90.41	79.89	87.96	95.96	88.85
Total	Mineral Import	1,378.68	1,894.55	2,257.46	6,091.51	1,335.52	15,968.33	17,884.91
	Non-mineral Import	24,481.02	39,614.87	55,214.82	62,017.09	37,095.59	42,395.40	46,026.46
	Total	25,859.70	41,509.42	57,472.28	68,108.59	38,431.11	58,363.73	63,911.38
	Share of Non-mineral Import	94.67	95.44	96.07	91.06	96.52	72.64	72.02

Source: Author's Computation; Data from World Integrated Trade Solution (WITS)

In 2013 and 2014 alone, Nigeria imported more mineral products from the Netherlands than any other EU+2 partners having recorded real import volume of about $7.24 and $8.99 respectively in those years. Import of non-mineral products from all the EU+2 partners increased differently over the same period. While Nigeria's real imports of non-mineral products France increased marginally, the increase in such import was at least double for most of the other countries. Also, Germany and the United Kingdom appear to be Nigeria's leading countries of origin for most of its non-mineral imports in the EU+2 during the period under consideration, exporting about $10.77 million and $10.08 million respectively in 2014.The foregoing therefore suggests that, in terms of mineral products, Nigeria experienced a surplus in its trade balance against each of the EU+2 top partners during 1996-2014. However, for non-mineral products, the country witnessed deficit in its trade balance against the same set of partners over the same period. This indicates that, over the period 1996-2014, these partners could be said to be indebted to Nigeria in mineral products but the country is indebted to them in terms of non-mineral products.

2.2.8 Analysis of Environmental Efficiency in Nigeria, Asia and the EU+2

Over the past two decades, real output in Nigeria has been on the increase with the real gross domestic product (GDP) line becoming steeper after 2003 which could be traced to the rising business confidence in the economy at this time. As shown in Figure 2.10, real GDP rose slightly to about $81.14 billion in 2003 from about $60.72 billion in 1996 before a pronounced upward trend to reach about $194.88 billion in 2014. Production of output in Nigeria has been identified to be largely driven by energy inputs, especially from non-renewable sources which are main sources of carbon emissions. Hence, total carbon emissions were generally higher during 1999-2014, when output growth in Nigeria were remarkable, than the earlier years. For instance, the level of carbon emission in Nigeria, which fluctuated frequently over the same period, was 40.42thousand kilotons in 1996 and rose marginally to 44.79 thousand kilotonsin 1996. However, carbon emission, which averaged about 89.45 during 2000-2014, reached a peak of about 104.70 thousand kilotons in 2005, after which it resumed a declining trend. The higher carbon emission over the past one and a half decades could be traced to the increased activities across the various sectors of the economy, especially the capital-intensive oil, manufacturing and service sectors relative to the labour-intensive agricultural sector. In the same vein, carbon emission per unit of energy use followed similar trend with carbon emission, rising significantly from 0.51 kilogram in 1996 to a peak of 1.05 kilogramsin 2002, representing an increase of about 106%. Although carbon intensity fell gradually afterwards to reach about 0.69 kilogram and 0.74 kilogram in 2009 and 2014 respectively, they remain higher than what obtains about 2 decades ago. Therefore, while recent trends suggest improvement in environmental efficiency in Nigeria, output production in the country appeared to be generally environmentally inefficientrelative to the periods prior to 1999.

Real GDP in Asia maintained an upward trend over the period 1996-2014, rising steadily from about $7.31 trillion in 1996 to $14.93 trillion in 2014 (increase of 104%), following a minor shock experienced in 1998 (Figure 2.11). Carbon emission in Asia increased in a similar fashion from about 7.23 million kilotons in 1996 to reach a peak of 14.65 million kilotons in 2011 (increase of 103%), with major improvement recorded in 1998 and 2012. This indicates thatincreased economic activities in Asia has continued to generate environmental pollution over the years, suggesting that the tremendous economic growth recorded has been largely driven by activities that are environmentally inefficient across all sectors, given the lax environmental policy in the region. This is further confirmed by trend of carbon intensity in the region which exhibited similar pattern of movement as carbon emission. Carbon emission per unit of energy use rose gently from 2.02 kilograms in 1996 to 2.18 kilograms in 2009 after which it became steeper to settle at about 2.59 kilograms in 2014.

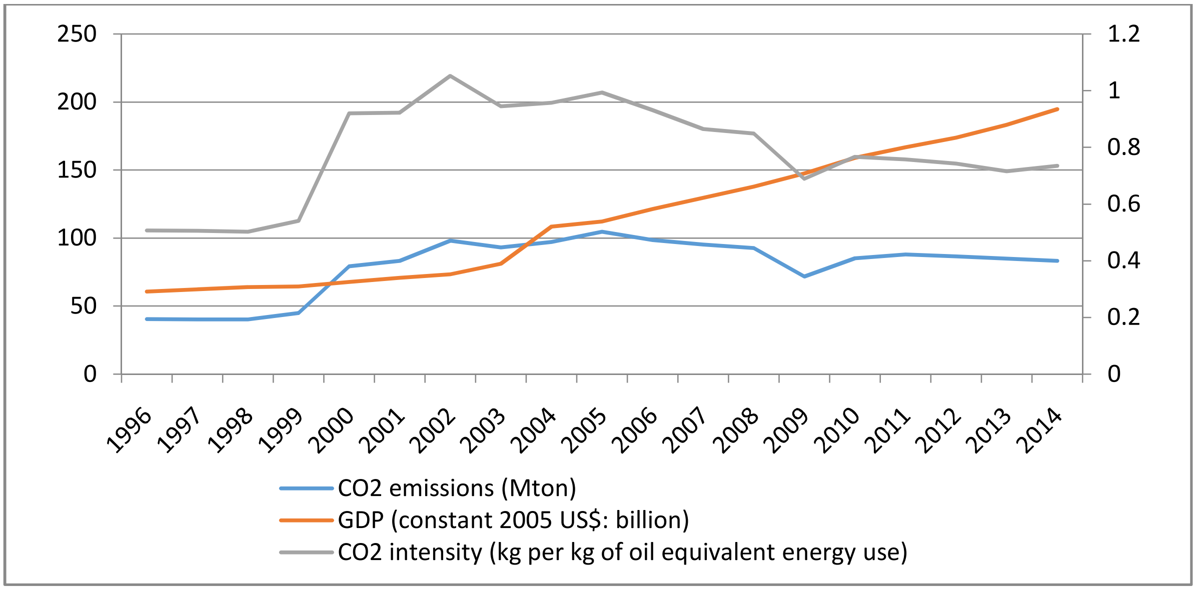

Figure 2.10.GDP, Carbon Emission and Carbon Intensity in Nigeria[19]
Source: Author's Computation; Data from World Bank World Development Indicators (2017)

[19] Carbon emissions and Carbon intensity of Nigerian export and import from her top partners in Asia and the EU are further presented in Table A1, A2 and A3.

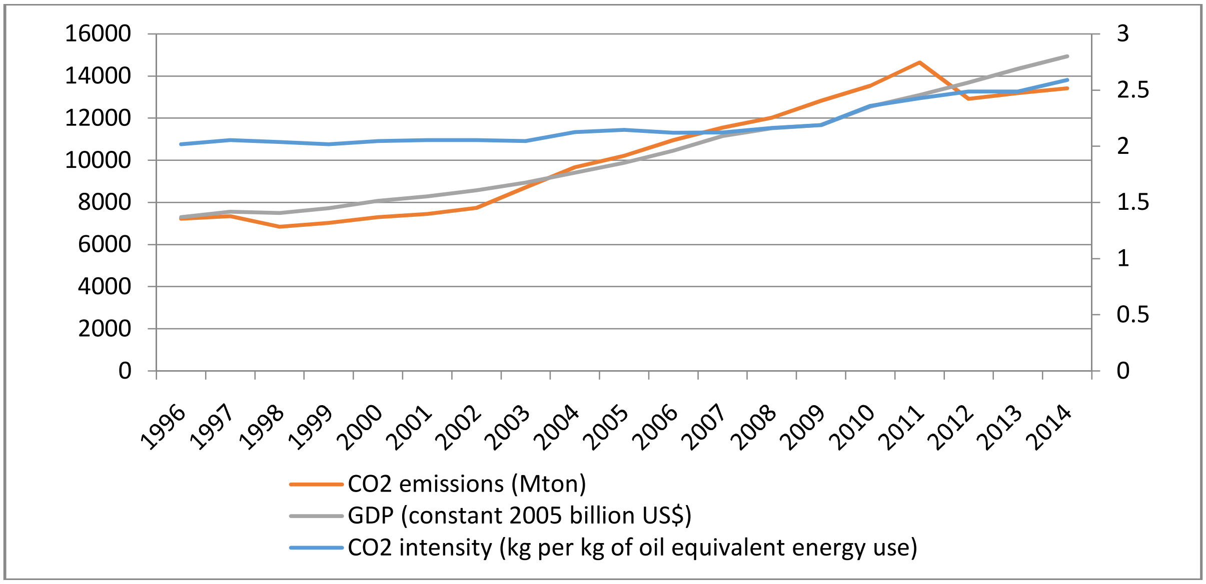

Figure 2.11.GDP, Carbon Emission and Carbon Intensity in Asia
Source: Author's Computation; Data from World Bank World Development Indicators (2017)

Real GDP in the EU+2 has maintained a stable upward trend since 1996 with minor breaks in 2009 and 2012 (Figure 2.12). In particular, real GDP stood at about $11.51 trillion in 1996 and reach a maximum point of about $15.37 trillion in 2014 (34% growth). Interestingly, as much as output was rising, carbon emission was on the downward trend with minor fluctuations over the period 1996-2014. The falling carbon emission in the EU+2 became very noticeable in recent years, beginning from 2007. For instance, carbon emission in the EU+2 rose gently from 4.05million kilotons in 1996 to a peak of 4.53million kilotons in 2006, but fell thereafter settled at about 3.57 million kilotons and3.68 kilotons in 2011 and 2014 respectively.

The combination of rising output and falling carbon emission is reflected in the level of carbon intensity which has largely followed a declining trend over the period 1996-2014. This development is traced largely to the huge commitment of the EU+2 to greenhouse gas reduction following the Kyoto Protocol of 1997 where much of the global environmental pollution are said to originate from the industrialized economies. The commitment of the EU+2 led to the setting of carbon emission targets and the formulation of various environmental policies that are critical for sustainable development. Hence, the rising output and falling carbon emission is an indication of energy and environmental efficiency in the production of GDP across the EU+2 countries.

Nigeria's top partners both in Asia and the EU+2 are major contributors to total carbon emissions in theirrespective region. For instance, China, which is Nigeria's leading import source from Asia contributed nothing less than 46% of the total carbon emission in Asia, reaching up to about 61% in 2014 (Table 2.11). The top seven partners in Asia emitted over 90% of the total carbon released into the environment in the region for most part of the period 1996-2014. India and Japan also contributed appreciably to total carbon emission in Asia, being Nigeria's major export destinations (as well as import origins) in Asia.

Similarly, for the case of the EU+2, the top ten trading partners are equally the leading emitters, contributing at least 67% to the total carbon emissions in the region during 1996-

2014. Germany, United Kingdom, Italy, France, Spain and the Netherlandscontributed 20%, 13%, 10%, 9% and 7% respectively to total carbon emission in the EU+2 in 2014. Given thatNigerian top partners in Asia contributed more to regional carbon emission, it therefore becomes obvious that these economies emit more carbon in their production process which may suggest that they are more environmentally inefficient than their EU+2 counterparts.

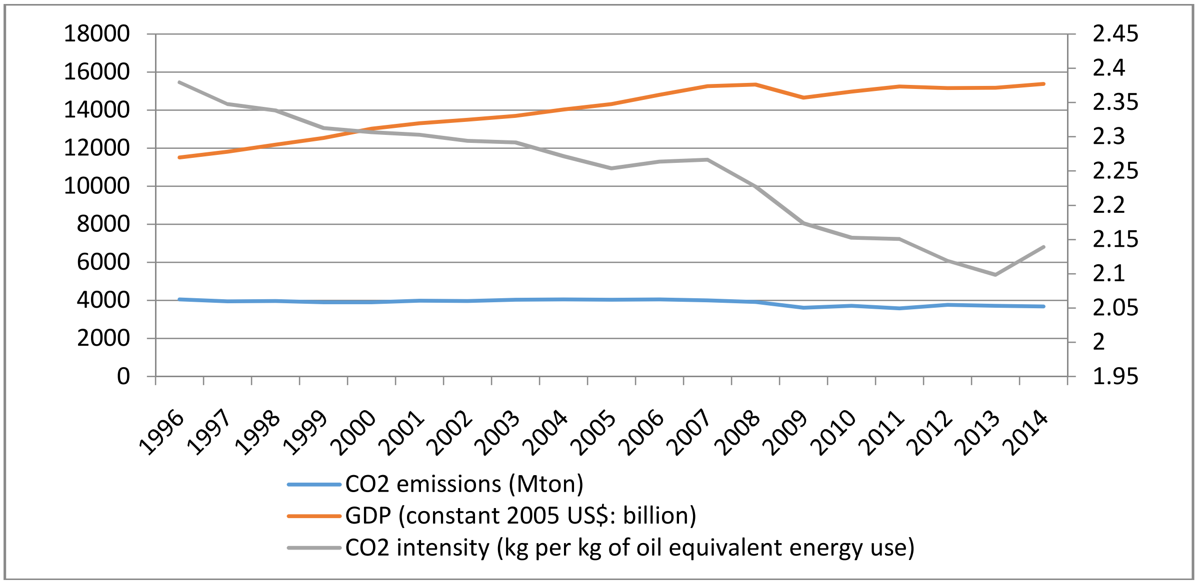

Figure 2.12.GDP, Carbon Emission and Carbon Intensity in the EU+2

Source: Author's Computation; Data from World Bank World Development Indicators (2017)

Table 2.11. Share of Nigeria's Top Trading Partners in Regional Emission (%)

Country	1996	2001	2006	2011	2012	2013	2014
Asia							
China	47.92	46.79	58.50	61.58	60.08	60.30	60.62
Hong Kong	0.41	0.51	0.35	0.27	0.30	0.29	0.28
India	13.87	16.15	13.72	14.16	14.55	14.65	14.61
Indonesia	3.50	3.96	3.15	3.85	3.47	3.51	3.52
Japan	16.68	16.13	11.23	8.11	9.16	8.87	8.66
Korea Rep.	5.59	6.04	4.29	4.02	4.13	4.10	4.08
Singapore	0.77	0.66	0.28	0.15	0.16	0.16	0.15
Total	**88.73**	**90.23**	**91.52**	**92.16**	**91.85**	**91.88**	**91.93**
EU+2							
France	9.27	9.45	9.27	9.28	8.84	8.97	9.26
Germany	21.97	21.39	20.14	20.48	19.64	20.38	20.18
Italy	10.52	11.28	11.58	11.14	9.81	9.28	10.44
Netherlands	4.33	4.21	4.12	4.82	4.50	4.57	4.69
Norway	0.82	1.05	1.09	1.26	1.33	1.60	1.47
Portugal	1.25	1.57	1.48	1.33	1.22	1.24	1.32
Spain	5.76	7.46	8.64	7.57	7.03	6.38	7.24
Sweden	1.38	1.28	1.22	1.45	1.25	1.19	1.30
Switzerland	0.99	1.08	1.03	1.03	1.00	1.09	1.06
United Kingdom	13.62	13.68	13.36	12.53	12.41	12.31	12.72
Total	**69.91**	**72.45**	**71.93**	**70.90**	**67.04**	**67.01**	**69.69**

Source: Author's Computation; Data from World Bank World Development Indicators (2017)

2.2.9Environmental Efficiency and Nigeria's Bilateral Trade with Asian and EU+2 Partners

Carbon intensity in Nigeria remained below 1 kilogram for most part of the period 1996-2014. Analysis of the relationship between this intensity (a raw measure of environmental efficiency) and bilateral trade between the country and its partners in Asia and the EU+2 shows a dynamic link.In 1996, carbon intensity stood at around 0.5 kilogram and the country's real export to EU+2 partners was as much as five times what it exported to Asia, while importing from the same partners about three times the real volume of imports from Asia (Figure 2.13).In 2006, carbon intensity rose to 0.93 kilogram while trade with partners, both in Asia and the EU+2, rose substantially with the exception of export to partners in the EU+2 that declined marginally from their 1996 values. Carbon intensity in Nigeria fell to about 0.72 in 2013 and export to partners in the EU+2 rose dramatically to about $195.14 million from $99.28 million recorded in 2006, which is more than twice total real exportsto Asian partners which has only risen marginally. Also, by 2013, real volume of imports from top partners in Asia has become larger than those from European partners whose real export to Nigeria has remain about the same as those recorded in 2006. Thus, it may be pertinent to empirically investigate whether or not environmental efficiency in Nigeria matter for bilateral trade with top Asian and EU+2 partners.

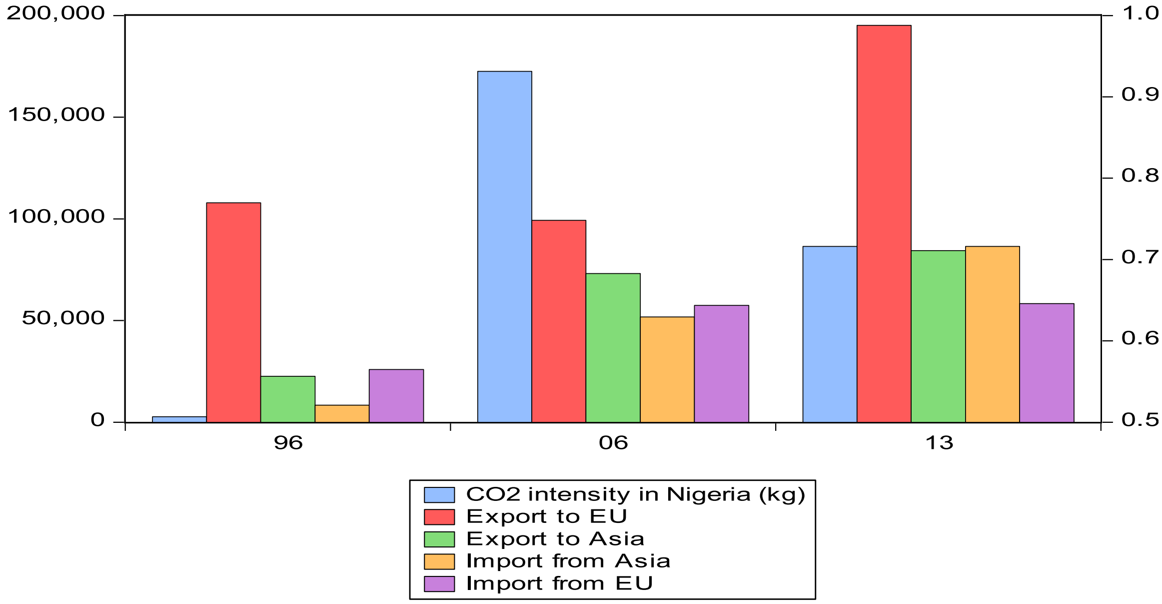

Figure 2.13. Carbon Intensity in Nigeria and Bilateral Trade with Asia and the EU+2
Source: Author's Computation; Data from WITS and World Bank WDI (2017)

Nigeria's bilateral trade with the Asia countries appears to have some direct relationship with the level environmental efficiency in these economies, which remained consistent during 1996-2014. For instance, in 1996, six Asian partners recorded over 2.0 kilograms of carbon emission per unit of energy used out of which five (Korea Republic, Japan, India, Singapore and Indonesia) were major export destination for Nigerian goods and services with each country importing over $1 million real worth of commodities from Nigeria in the same year (Figure 2.14). Similarly, in the same year, Nigeria imported more than $1 million goods and services, in real volumes, from Japan, China, India and Hong Kong which were among the countries with the highest carbon intensity in the region.

In 2013, China, which had the highest carbon intensity among the Nigeria's trading partners in Asia, exported more commodities to Nigeria than any other Asian partner (Figure 2.15). In similar vein, India, which was among the countries with the highest carbon intensity in Asia, imported more goods and services from Nigeria than any of its neighbours. It is also observed that partners (Singapore, Korea Republic and Indonesia) with low carbon intensity recorded low real volume of trade with Nigeria. Surprisingly, Hong Kong and Japan, which are high carbon intensity economy (3.23 kilograms and 2.73 kilograms respectively), were among the Asian partners with the least real volume of trade (export and import) with Nigeria. This shows a high possibility that Nigerian trade relations with top partners in Asia may be affected by environmental efficiency in these economies.

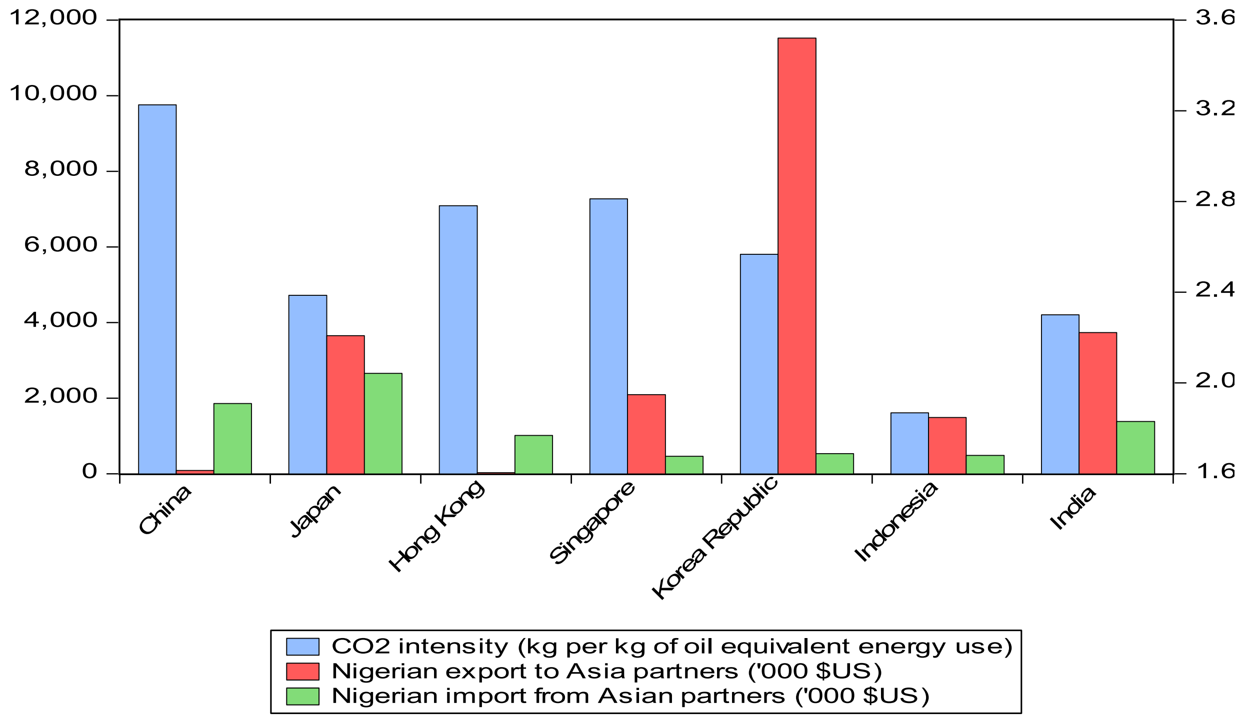

Figure 2.14. Carbon Intensity and Nigeria's Bilateral Trade with Top Partners in Asia (1996)
Source: Author's Computation; Data from WITS and World Bank WDI (2017)

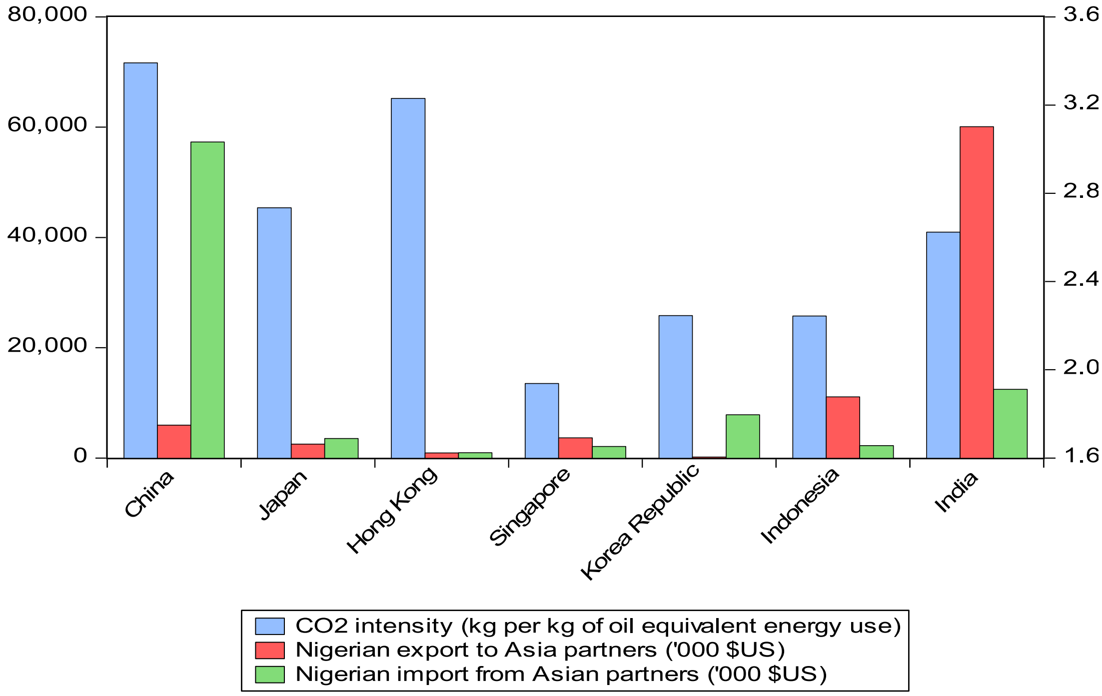

Figure 2.15. Carbon Intensity and Nigeria's Bilateral Trade with Top Partners in the Asia (2013)
Source: Author's Computation; Data from WITS and World Bank WDI (2017)

Similar to the case of Asia, Nigeria's trade with top EU+2 partners seems to have direct relationship with the level of environmental efficiency in these economies. For instance, the top five economies with the highest carbon emission per unit of energy used in 1996 are Italy, Germany, Portugal, the United Kingdom, the Netherlands and Spain, having recorded over 2.3 kilograms of carbon intensity in the same year (Figure 2.16). Among these economies, Nigeria exported more to Spain ($32.79 million), Italy ($19.07 million) and the Netherlands ($17.85 million) than any other partners in the EU+2. In the same vein, Nigeria sourced more of its imports from the United Kingdom ($7.07 million) and Germany (5.89 million) than from any other EU+2 partners.Nigeria's real trade volume with Switzerland, Norway and Sweden are very low as these countries are among those with carbon intensity below 2.0 kilograms. France appeared to be the only EU+2 partner with low carbon intensity and high trade relation with Nigeria in 1996.

As in 1996, the leading carbon intensity economies among Nigeria's top trading partners in the EU+2 are equally those that recorded the largest volume of trade with the country in 2013 (Figure 2.17). For instance, export to the Netherlands, Italy, Spain, France and the United Kingdom reached $50.82 million, 33.39 million, 33.32 million, 28.11 million respectively in 2013 with only France (1,32 kilograms) remaining among the low carbon intensity economies. Also, real import of Nigeria from the United Kingdom ($13.73 million), the Netherlands ($13.34 million) and Germany ($9.12 million) were highest among the EU+2 countries. However, despite the rising level of carbon intensity in Norway and Switzerland, Nigeria's trade relation with them remains low while trade with trade with Sweden remain as low as the carbon intensity of the country.

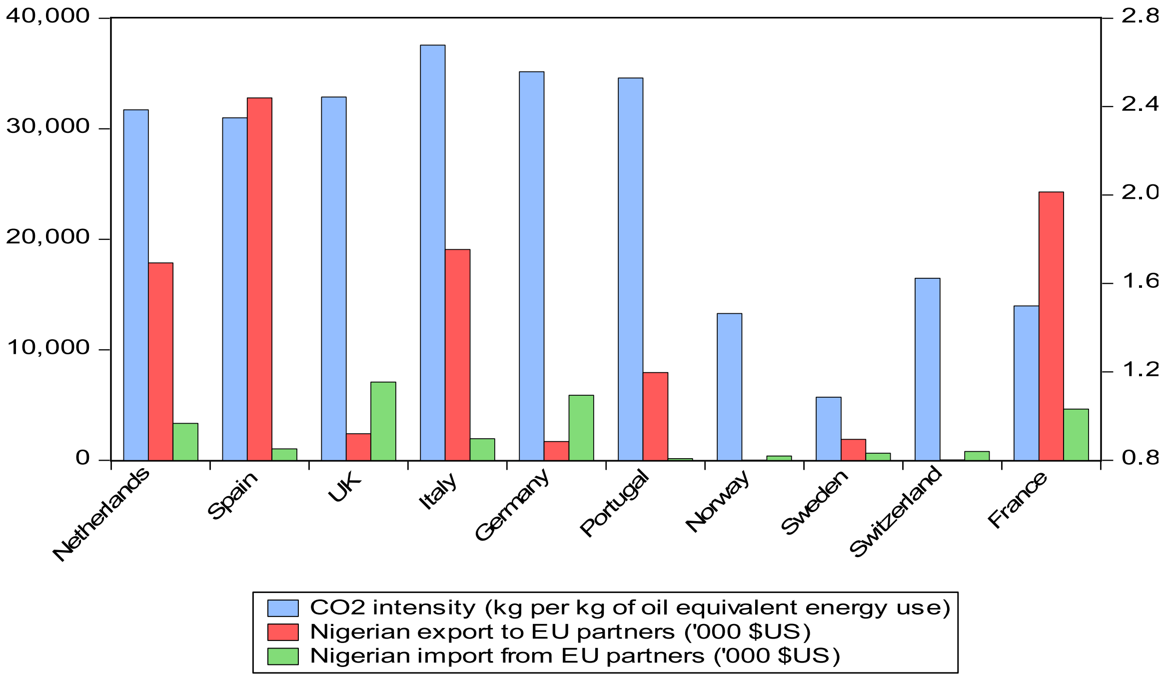

Figure 2.16. Carbon Intensity and Nigeria's Bilateral Trade with Top Partners in the EU+2 (1996)
Source: Author's Computation; Data from WITS and World Bank WDI (2017)

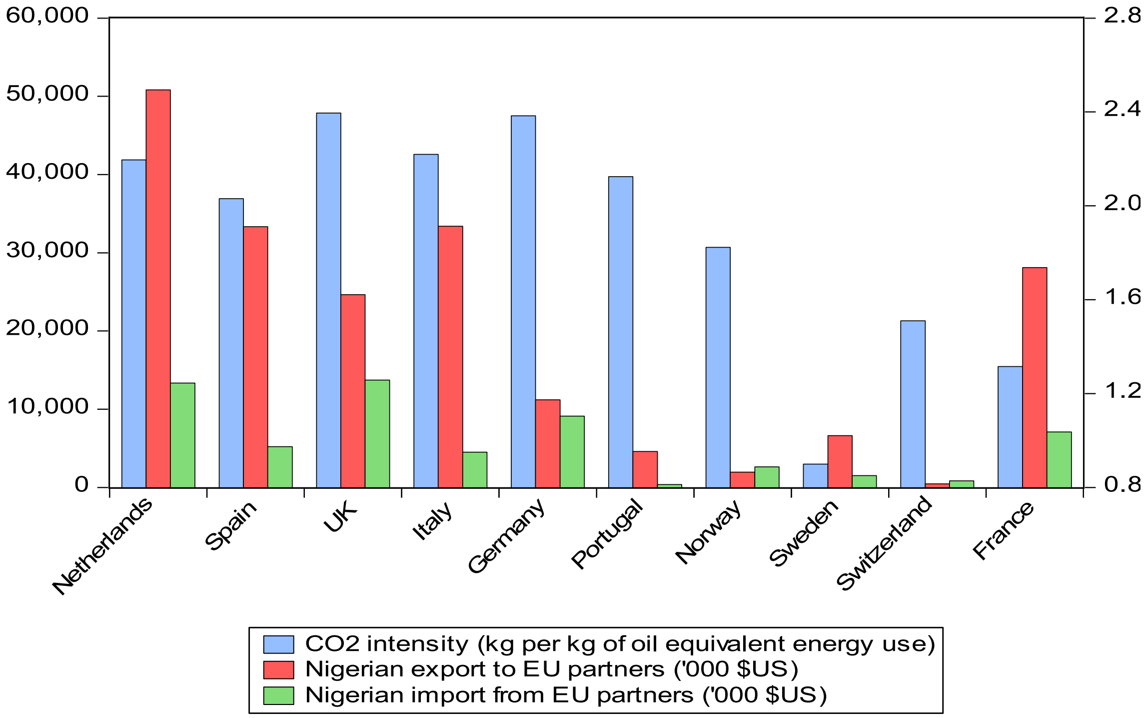

Figure 2.17. Carbon Intensity and Nigeria's Bilateral Trade with Top Partners in the EU+2 (2013)
Source: Author's Computation; Data from WITS and World Bank WDI (2017)

Following from the foregoing, it can be said that environmental efficiency level in Nigeria may be important for trade with the Asian economies, but only in the case of trade (import) in non-mineral products. However, environmental efficiency in the economies of the trading partners may be very critical to Nigeria's bilateral trade in mineral and non-mineral product with both EU+2 and Asian countries. The recent increase in non-mineral import from Asia could indicate the porosity of Nigerian economy, especially for products from environmentally inefficient techniques. The rising Nigeria's export to Asia, as well as the EU+2, and the continuous rise in output of these economies could reflect the increasing need for oil which is largely sourced from Nigeria to power economic activities. Thus, the lax environmental regulation, as well as the associated environmentally inefficient and high energy intensity of the Asian production process, could favour energy (oil) import from Nigeria, irrespective of the level of environmental efficiency of the oil sector in Nigeria. On the other hand, Nigeria seems to be a major export market for goods produced from highly environmentally inefficient production process. The reason for this could be traced to the wave of industrialization in Asia and the fact that Nigeria is equally lax in terms of environmental regulation, while the country continues to be a favourable destination for sub-standard products which are often paid for from the revenue obtained from oil export.

For the case of the EU+2, Nigeria produces Bonny light crude oil with very low sulphur content, low corrosiveness in refinery and low environmental impact of its by-products in refinery effluent. This makes it highly desirable, among other crude oil types, for any industrial economy that is committed carbon reduction. The efforts of the EU+2 in reducing environmental pollution, especially from production activities, could provide partial explanation for the rising export of Nigeria destined for the EU+2 in recent years irrespective of the environmental efficiency level of the country.More importantly, the existence of sound economic cooperation between Nigeria, and the rest of Africa, with the EU+2 may provide considerable justification for this development. Also, as much as more mineral products are exported to this region, it appears that much of the proceeds are spent on the relatively clean imports from the EU+2.

2.3 Literature Review

2.3.1 Review of Theoretical Literature

Beginning from the classical trade theories, several theories have been developed to explain the drivers of international trade among countries of the world. However, those linking international trade with environmental quality are few, though some of them inherently reflect implication of the environment for trade. These trade theories include theclassical theory (Ricardian Model), the neo-classical theory (Hecksher-Ohlin Model), Pollution Haven Hypothesis and Porter Hypothesis.

2.3.1.1 The Classical Theory (Ricardian Model of Comparative Advantage)

Theclassical theory of trade as represented by the Ricardian model, which is often associated with the 19th century British economist David Ricardo, is developed as a criticism to the flaws of Adam Smith's Theory of Absolute Cost Advantage. A country has absolute advantage in the production of a commodity if it can produce greater quantities relative to another country, given the same level of resources. Thus, such country should specialize in that commodity and export the same. The Ricardian model posits that production function (technology) differs across countries and countries should specialize according to comparative cost advantage. Thus, a country has comparative cost advantage in the production of a commodity over another country if the opportunity cost of producing that good is lowest relative to the other country (Deardorff, 2005).

The model starts with the simple assumption that there are only two countries in the world producing two similar goods. It is further assumed that labour is the only factor of production which is freely mobile across industries, such that resource endowment is the same in both countries. In this model, constant returns to scale are assumed, giving rise to a linear production possibility frontier while production and consumption are free from market distortions. Also, tastes are identical and homogenous in each country (Markusen et al, 1995). These assumptions therefore imply that specialisation and exchange can only arise where productivity differs between the two countries given the differences in technology. In essence, while differences in marginal product of labour may suggest absolute advantage, specialisation and trade may be difficult where a country can produce more from a unit of labour in both goods relative to the other country. Comparative cost advantage therefore implies that the ratios of marginal product of labour differ in the two countries even if a unit of labour in one country can produce more of both goods than its counterpart in the other country (Markusen et al, 1995). Thus, specialisation is possible and trade is gainful for both countries.

The differences in labour productivity (and ratio of marginal product of labour) may reflect the type of production technology, as well as the quality of environment, adopted by a country. In standard microeconomic efficiency theory, a firm seeks to maximise output from the given quantity of inputs or minimize the quantity of inputs to produce a given amount of output (Varian, 1992). Since pollutants are equally produced from the production process, a carbon inefficient technology may increase the cost of production through the release of harmful substances, such as carbon, to the environment which has adverse implication on the health, hence productivity of labour (Lannelongue et al, 2017). Thus, countries with environmentally-friendly technology tend to be more productive than environmentally inefficient countries. Subsequently, carbon efficient countries tend to have comparative advantage in 'clean goods' while carbon inefficient countries tend towards 'dirty goods'. According to Yang et al (2019), regions with better technology andlow emission intensities usually outsource the production of pollution-intensive but low value-addedgoods to regions with high emission intensities through inter-regional trade. However, environmentally-sensitive countries may be unwilling to import 'dirty goods' for which some countries are specialists.

The Ricardian model assumes that labour is the only factor of production, and that it exhibits constant marginal productivities. The implications of this assumption include constant opportunity costs of production activities and the possibility of complete specialisation in trade. It also implies that positive income gains can be obtained from trade by all workers in both countries, except one country does not specialize completely as a result of its large size. It is however unrealistic in modern production processes to have labour as the only factor of production. This represents the major shortcoming of the model.

2.3.1.2The Neo-Classical Theory and its Extensions

Heckscher-Ohlin Model

The Heckscher-Ohlin (H-O) trade model, derived from the neo-classical trade theory andnamed after Swedish economists Eli Heckscher and Bertil Ohlin who developed its fundamentals, came into pre-eminence in the 20th century. The model built on the Ricardian model but departs from it in two ways. First, rather than the Ricardian assumption of a single factor (labour) economy, the H-O model introduced a second factor – capital into production processes. Thus, production function can be specified in terms of labour and capital. Second, the H-O model assumes that production technology is the same across world competitors, rather than the assumption of differences in production functions. In this model therefore, trade cannot be said to be a result of disparity in international technology but in the relative abundance of factors of production.

The introduction of a second factor presents more realistic explanation of trade. For instance, the production frontier becomes concave rather than linear which indicates rising opportunity costs. In reality, a country does not commit all their resources to the production of a particular commodity but tend to produce both goods in free trade. Thus, countries typically diversify across commodities instead of complete specialisation in a particular good. In the H-O model therefore, comparative advantage and trade are determined by international differences in factor endowments (Markusen et al, 1995).

The H-O theorem states that a country will export the commodity that intensively uses its relatively abundant factor. This theorem suggests that countries, such as developing countries, with abundant supply of low and unskilled labour tends to be net exporter of labour-intensive goods while those countries with large areas of agricultural land are usually net exporter of agricultural produce.

The assumption of identical production technology has been heavily criticized in the literature as it would require both countries to have similar industrial output. The H-O model also assumed absence of transaction costs as purchasing parity holds in both countries. These assumptions are unrealistic as technology obviously differs among countries while transaction cost, does not only exist, but also increase with distance. Furthermore, empirical findings of Leontief (1953) and Linder (1961) represents the major criticism of the model in what is called Leontief paradox and Linder hypothesis respectively.Leontief found that USA, the most capital-abundant economy at that time, actually exported labour-intensive goods and imported capital-intensive which contradict the proposition of the H-O model. The Linder hypothesis claimed that demand played important role than comparative advantage in determining trade as countries are more likely to trade with those that share similar demands.

Despite these criticisms, the H-O model has been employed in explaining the link between environmental quality and international trade. Different industries have varying degrees of pollution intensity which may be compounded by the characteristics of an economy in terms of income level and laxity of environmental regulation. The H-O model recognizes that industry characteristics are potentially relevant following its classical inference that countries focus on the production and export of goods that intensively use the abundant factors (Mulatu et al, 2004). Through rising industry costs, stringent regulation increases imports and decreases exports of industries that are intensive in pollutant emission, making environmental regulation a source of comparative disadvantage in pollution-intensive goods (Copeland and Taylor, 1994, 1995).Mulatu et al, (2004) adopted this special case of H-O model that incorporates both pollution haven and factor-abundance presented by Antweiler et al, (2001) and Copeland and Taylor (2003) to investigate the responsiveness of international trade to stringency of environmental regulation.

Extensions of Heckscher-Ohlin Model

Following the paradox of Leontief (1953), the H-O model has been variously tested. Theoretically, H-O model has been extended in various areas to capture different developments and progresses in economicswith the first major extension containedin Vanek (1959) where factor content of trade is predicted rather than the pattern of trade in goods.Further extensions of the model include intra-industry trade (Dixit and Norman, 1980 and Helpman and Krugman, 1985),imperfect competition in the differentiated sector (Brander and Krugman, 1983 and Etro, 2017),variable returns to scale (Young, 1991),homogeneous goods and Cournot competition (Lahiri and Ono, 1995) and CES preferences with bothBertrand andCournot competition (Etro, 2015), and environmental tax (Kohn, 2000). In particular, Kohn (2000) extended the Heckscher–Ohlin–Samuelson modelto accommodate the role of environmental tax in a three-country and two-good model and this is further reviewed in what follows;

In the Heckscher-Ohlin-Samuelson (H-O-S) model, there exists a 2-country world with 2 goods, and 2 factors with each country having a free-market economy consisting of consumers and competitive firms. Since factors cannot move across countries, the only point of contact between countries is trade in goods. It is further assumed that technologies are identical, but the production of each good involves intensive use of one of the factors. Thus, Kohn (2000) began by assuming three countries with two industries using production functions that are identical, linear and homogeneous. Industry *Y* is pollution intensive and uses higher ratio of capital to labour. In essence, the country with the highest ratio of capital to labour has the natural comparative advantage in the production of the pollution intensive output *Y*(Samuelson, 1949). In the absence of technological abatement, pollution can only be reduced either by consuming less of the polluting good and more of the non-polluting good (substitutions in consumption) or by importing rather than manufacturing the pollution intensive good. Moreover, it is assumed that pollution damage, which is only caused by emissions generated within the same country, increases in proportion tothe output generated before the production of the pollution-sensitivegood but geometrically with respect to the domesticpollution level.

Each country has a common community utility function of the form $U=U(x, y)$, where x and $y$represents consumption quantities following international trade. Since preferences are homothetic and identical across countries, the resulting H-O-S trade flows are compatible with natural comparative advantage. Given that wage rate in any of the countries is w, the competitive prices of capital and good X in that country are$r = wX_K/X_L = wY_K/Y_L$ and $P_x = w/X_L = r/ X_K$ respectively. Also, if Piguvian tax isset to equal the level of marginal pollution damage and it is given as $T = - P_xX_E$, then thecompetitive price of good Ywill be$P_y = w/Y_L + TE_y = r/Y_K + TE_y$.

Each country is differently endowed such that the fixed quantities of inputs are Lo** and Ko**in the country that exhibits the highest capital-labourratio, Lo* and Ko* in the country which possesses the secondhighest ratio, while$L$o and Ko is used for the country withthe smallest ratio. Consequently, the country with thelargest capital-labor ratio trades Y^T* for $X^T*$with the country exhibiting the next higher capital-labor ratio and $Y^T$for $X^T$with the third country.

Thus;

$$y^{**} = Y^{**} = Y^T* = Y^T \text{and}$$
$$x^{**} = X^{**} = X^T* = X^T$$
$$y^* = Y^* = Y^T* \text{ and } x^* = X^* = X^T*$$
$$y = Y = Y^T \text{and } x = X = X^T$$

Owing to the assumption of homothetic and identical preferences are across countries, then;

$$\frac{Y^{**} + Y^* + Y}{X^{**} + X^* + X} = \frac{y^{**}}{x^{**}} = \frac{y^*}{x^*} = \frac{y}{x}$$

Given a 2-products. 3-countries situation, the pattern of trade in indeterminate which necessitate an assumption that no trade exists between the two countriesexhibiting lower capital-labor ratios. Althoughthisassumption may appear extreme, it is necessaryin multiple-countrymodels (Helpman 1999). Also, given that consumers seek to maximize utility subject to constraints imposed by their income, $Uy/Ux = py/px$, in each country,free trade allowsequality of relative prices and terms of tradeacross countries, such that

$$\frac{P_y}{P_x} = \frac{X^T}{Y^T} = \frac{P_y*}{P_x*} = \frac{X^T*}{Y^T*} = \frac{P_y**}{P_x**}$$

This extension however fails to explain how the environmental tax imposed on firms influence their environmental efficiency and productivity.

2.3.1.3 Pollution Haven and Pollution Halo Hypotheses

Industrialization in less developed and developing countries has accelerated in the last few decades as many industrial activities have moved into these countries in form of foreign direct investment from developed countries. This movement is explained by the pollution haven and halo hypotheses. The pollution haven hypothesis suggests that,under free trade condition, pollution-intensive industries will relocate to countries with less stringent environmentalregulations (Copeland and Taylor, 2004).In contrast, foreign industries diffuse optimal management system in addition to superior environmental technology in the host country, resulting in "pollution halos effects" to firms operating in the host country (Christmann and Taylor, 2001; Eskeland and Harrison, 2003). A firm tends to relocate its plant to a foreign country in order tocircumvent environmental regulations that are considered stringent in its home country but use production techniques that are cleaner relative to the technology of their counterpartdomestic firms in the host country. These two hypotheses evolve from the environmental Kuznets curve (EKC) that provides a role for economic activities or income in environmental degradation of which foreign trade and investment play key roles (Song et al., 2008 and Narayan and Narayan, 2010).

Production process generates pollution as a joint product.Pollution abatement becomes necessary but it requires real resources. Thus, active abatement plus joint production leads to a production process where pollution appears as an input into production. Thus, pollution haven hypothesis assumes two countries, North and South, with North relatively more human capital abundant than South. Thus, each country specializes and trade in a set of either relatively clean or dirty goods. Moreover, the effect of pollution is assumed to be local while the environment is a normal good. As a policy response, a social planner in each country taxes polluting industries an amount that equals the marginal damage done and generates higher real income in the process (Taylor, 2005). Thus, cost of production tends to rise with the amount of pollution generated, as well as the stringency of such environmental regulation. For instance, developed economies (North) enacted strict environmental regulation following huge environmental concerns which increased the cost of production of 'dirty goods'. On the other hand, developing countries (South) have become attractive destinations for such industries given their low wages (abundant labour) and lax environmental regulation, as well as need for financial resources for industrial development (Akbostanci et al, 2004).

This model reflects the reality of unequal incomedistribution across the world, disparity in industrial pollution intensity of production, and environmental quality as a normal good.These assumptions therefore allow predictions on trade patterns and pollution levels. Pollution Haven Hypothesis can arise whendifferences occur among countries only in terms of human capital levels, where a movement from closed economy (autarky) to free trade in goods results inthe relocation of production of dirty good from the high incomecountries who have high level of tight environmentalregulation to the low income lax environmental regulation country. Consequently, lax regulation country exhibits rise in pollution whileit falls inthe tight regulation country, raising world pollution in the process as world's dirtiest industries move to the country with the lowest environmental standards (Taylor, 2005). However, high income countries are likely to be the net importer of 'dirty goods' in the process. He (2006) employed the hypothesis to investigate the effect of foreign direct investment on the environment among Chinese provinces while Cole (2004) assessed the presence of pollution haven hypothesis in the North–South trade flows, especially as regards pollution intensive products. Also, Akbostanci et al, (2004) examined the roles of dirty industries in Turkey's exports using the hypothesis.

This hypothesis has been faulted on a number of grounds. First, it assumes free trade, nowhere in the world is trade truly free while trade liberalisation involves some endogenous conditions which may consist of a number of technical barriers to trade (TBT). Moreover, the hypothesis employed industrial pollution in its formulation but empirical test found other pollution data sources more useful. For example, data on renewable resource use, consumption generated pollution or trans-boundary pollution have been variously employed(Taylor, 2005). Also, in spite of the fact that trade is influenced by several other factors, the hypothesis emphasizes differences in environmental policy as a source of comparative advantage and trade.

2.3.1.4 Porter Hypothesis

In the environmental regulation-performance literature, thestandard traditional view posits thatstrict environmental protection imposes major constraints on industrial behaviour which hinders firms' productivity and competitiveness, and hence has adverse effect on economic performance (Rubashkina et al, 2015).These constraints manifest either in the form of higher direct cost of adjusting production process which could involve huge R&D investment or reflects the rising financial obligations that limit firms' budgets. Therefore, there are associated opportunity costs in complying with environmentalregulationas firmscannot investinotherprofitable opportunities.

Well-designed andwell-enforced regulation could actually benefit boththeenvironmentandthe firm through enhanced competitiveness (Porter, 1991 and Porter andvanderLinde, 1995).This proposition is popularly referred to as the Porter Hypothesis which summarizes that stringent environmental regulation can increase firm's global competitiveness.

In a typical production process, energy is combined with critical inputs such as labour and capital to produce certain quantities of desired output with pollution being jointly produced (Adewuyi and Awodumi, 2017).Consequently, these productive resources are used inefficiently as the fraction of it used in the production of pollution can be employed to improve productivity, hence reduce pollution. Enforcement of stringent environmental regulations can spur innovation among firms leading to the adoption of environmentally-friendly production process such as the use of energy-reducing or carbon-efficienttechniques or both. In resource (oil) rich economies, such techniques could also help in reducing oil spillage. Such regulation could be in the form of sanctions such as pollution-production tax or incentives which could be a pollution-reducing subsidy.

One major assumption of the hypothesis is that the regulation is well-designed and efficiently executed. Thus, in an efficient economic system, firms are forced to endogenize the environmental effect of their production activities. This makes them to adopt improved technology that is environmentally friendly and increase productivity as well as reduce average cost overtime. Consequently, high quality 'clean goods' are produced which increases competition among firm in the industry. In the process, firms can compete favourably in the international market as they can meet international standards.

Like other related theories, the Porter Hypothesis has been criticized.It is incompatible with the assumption of profit-maximizing firms (Palmer et al, 1995).Firms are profit-maximizing and does not necessarily need regulation such as environmental protection laws to induce them to make optimal choices. Firms may not be making optimal choices for reasons that are not environmentally related includingimperfect information or organizational or market failures. Porter however argues that environmental regulation may help firms identify inefficient uses of costly resources while also help in producing and disseminating new information on best-practicetechnologies. It is however often questioned whetherregulators are in a better position than managers to find these profitable business opportunities.

Opponents of the hypothesis also identify much confusion in the literature about what the Porter Hypothesis actually says. First, the hypothesis does not assert that all regulation leads to innovation but only well-designed ones do. Second, it does notstate that this innovation necessarilyoffsets the cost of regulation as regulation is not alwaysa free lunch (Ambec et al, 2011). Thus, there may be situations where the costs of regulation to firms outweigh benefits of compliance.

Empirical tests of Porter Hypothesis have been carried out by a number of studies. For instance, Brunnermeier and Cohen (2003)could not establish significant impact of environmental regulation on innovation and technology among 146 U.S. manufacturing firms. The hypothesis however found support in Popp (2003), who focused on 186 gas plants in the U.S. as well as Arimura et al. (2007) 4,000 among manufacturing facilities in 7 OECD countries andPopp (2006) in USA, Japan and Germany. Also, Rubashkina et al, (2015)establish the hypothesis on the innovation of 17 manufacturing sectors across Europe. Similarly, in terms of productivity, the hypothesis does not find support in Gray and Shadbegian (2003) among 116 U.S. paper mill firms and Crotty and Smith (2008) who investigated 37 firms in the UK automobile sector. However, the hypothesis is confirmed in Berman andBui (2001) for the US petroleum refining industry and Lanoie et al.(2008) who examined the case of 17 Quebec manufacturing industries.

The theoretical literature has largely explained the link between environmental regulation and trade in the context of the Ricardianmodel, Hechsher-Ohlinmodel, Porter Hypothesis and Pollution Haven Hypothesis. In particular, the H-O model has been widely used in empirical literature because of its ability to explain how stringent regulation could create comparative disadvantage in pollution-intensive good while producing comparative advantage in clean goods relative to other countries. This modeldoes not clearly accommodate the case of developing resource-rich economies, such as Nigeria, that are characterised by lax environmental regulation and high environmental inefficiency in production processes. Moreover, these economies have already developed comparative advantage in pollution-intensive goods produced from their abundant resources such as crude oil and they have remained net exporter of such commodities. In essence, any effort towards environmental efficiency in that sector can only enhance or retard the existing advantage, where the H-Omodel alone may not be adequate. Hence, this study adds to theoretical literature by expanding the Heckscher-Ohlin (H-O)modelincorporating the role of environmental efficiency (as a form of trade distortion) in bilateral trade between Nigeria and its top trading partners. It provides a role for environmental efficiency, similar to government policy, in an existing H-O framework.

2.3.2 Review of Methodological Literature

Studies on efficiency and its various implications are usually conducted in two-stage analysis. The first stage involves generating efficiency scores while the second stage often involves utilizing the efficiency scores in setting up and estimating appropriate regression models. Thus, this section reviews the literature on methodologies in two parts. The first part is a review of literature on the relevant measures of efficiency while the second part focuses on estimation techniques.

2.3.2.1 Measures of Efficiency

Existingliteratureidentifies two dominant techniques for generating efficiency scores - theparametric and thenon-parametricapproaches(Berger and Humphey, 1997).

a.The Parametric Approach

The parametric(also called econometric) approach considers a production function while recognisingthat deviation away from the production technology (captured by the error term) is composedof two parts which include randomness (or statistical noise) and the other inefficiency.

Consider a production function (F)based on the technology set A which maximises output y from the given input set x:

$$f(x) = \max\{y / (x, y) \epsilon A\}$$

where x is an$n$ dimensional input vector and y is the m = 1 dimensional output. A major assumption about this production function is that it has a specific functional form with unknown detaildefined by a vector of parameters β:

$$f(x) = f(x; \beta)$$

Assume a Cobb-Douglass production function

$$y = \beta_0 x_1^{\beta_1} x_2^{\beta_2} \dots x_m^{\beta_m}$$

where the parameters areβ_0, β_1, β_2,…,β_m. The maximum likelihood principle, which involves choosing the value of estimated β which makes the actual observations as likely as possible, is often used in the parametric approach. According to Bogetoft and Otto (2011), three main processes of the parametric approach is often suggested in the literature. The first process considers any deviation as noise which corresponds to an ordinary regression model. Second is to consider any deviation as an expression of inefficiency which is referred to as deterministic frontier. The third posits that deviations arise from both noise and inefficiency. This is called the stochastic frontier analysis (SFA).

The noise term(v) can make the observed output larger or smaller than f(x; β), whereas the inefficiency term ($u \geq 0$)will always make the observed output smaller than f(x; β)[20]. These terms can enter the production function additively,as in the Farrel output efficiency[21]or multiplicatively, as in the Shephard output efficiency. Thus, given the production function, the efficiency of a particular firm can be evaluated.

b. The Non-Parametric Approach

The most common version of this approach is the non-parametric linear programming tool (data envelopment analysis: DEA).DEA essentially computes the economic efficiency of a given processor system relative to the performance of other processes or systems producing the same good or service, rather than against an idealised standard of performance. That is, DEA involves the use of linear programming methods to construct a non-parametric piece-wise frontier over the data and efficiency of each decision-making unit (DMU) is calculated relative to the "best practising" producer(Coelli et al, 2005). It is also possible to apply to situations with multiple inputs and outputs. Data Envelopment Analysis, which was first coined by Charnes, et al, (1978) with an input-oriented model and constant return to scale (CRS), has continue to develop ever since. Subsequently, Färeand Grosskopf, (1983) and Banker et al, (1984) developed the variable returns to scale (VRS) DEA models.

[20]The inefficiency term is assumed to be positive

[21] Farrel output efficiency is the inverse of the Shephard output efficiency

This technique has been applied variously in many disciplines following its many theoretical developments.Two main measures of efficiency exist with different characteristics - radial and non-radial measures. Historically, the radial models, represented by the CCR[22] model (Charnes et al., 1978), was the first DEA model, whereas the non-radial models, represented by the slacks-based measure (SBM model) andpopularised by Tone(2001),was developed much later.In the input-oriented case, the CCR deals mainly with proportionate reduction of input resources. For example, where a decision-making unit (DMU) only employs two inputs, the task of this model is therefore to obtain the maximum rate of reduction in the same proportion, that is,seeking a radial contraction in these inputs such that the current outputsare produced.On the contrary, the non-radial models do not consider the assumption of proportionate contraction in inputs but obtains the maximum rate of input reduction which may put away varying proportions of the original input resources.

The super SBM model derives from the SBM model. The first step is to removeDMUqfrom the population unit which is being evaluated. The super SBM model thereafterwants to find a virtual unit DMU* with inputs X^* and outputs Y^* which will be efficient in SBM after the removal. Apparently, inputs into unit DMU* willbe higher or equal to those into the evaluated unit DMUq and all outputs will be lower or equal to those of DMUq. The super-efficiency rate is defined as the distance between the inputs and outputs of both units –DMU* and DMUq.

The main shortcoming of the CCR model is that it neglects non-radial slacks. For the SBM model, a major shortcoming is the fact that the projected DMU may lose the proportionality of the original input mix. This characteristic of the non-radial models becomes a problem as it becomes difficult identifying the optimal input combination, especially in the event of a loss of the original proportionality is inappropriate for the analysis. However, the difficultyin observing such a case in practice represents a major shortcoming of non-radial models which brings a problem when assessing efficiency change over time. The non-zero pattern of slacks at time period *t* may significantly differ

[22]CCR is an acronym for Charnes, A., Cooper W. W. and Rhodes E. (1978) who pioneered the radial model of DEA under the assumption of constant return to scale.

from that of time period $t + 1$. Thus, it is difficult to tell which pattern is reasonable and may distort interpretation of results, especially, when we consider these slacks as the sources of inefficiency.

In energy and environmental studies, the various developments of DEA have been widely used to benchmark energy and CO2 emission performance. Among these studies are Li et al, (2013b); Chen et al, (2014); Song and Zheng, (2015); Shao and Wang, (2016); Chen and Jia, (2016) and Song et al, (2016). With respect to super-SBM DEA models, related recent studies include Yang et al, (2014); Song et al, (2015b) and Li et al, (2013b). Turner (1994) first employed DEA to estimate the sub-vector Shephard output distance function for pollutant shadow pricing while Boyd et al. (1996) first calculated the shadow price by using DEA.

2.3.2.2DEA Input and Output Indicators

In DEA environmental efficiency literature, three major ways of combining inputs and output indicators (input-output mix) are identified. First, most studies utilize labour, capital and energy as input variables tosimultaneously produce both desirable (GDP) and undesirable (pollutants) output.That is, both outputs are treated together in a multiple-output analysis using DEA.Some examples of these studies include Zhou et al (2013),Wang et al (2014),Wang et al (2013), Chang et al (2014), Song et al (2015a), Li et al (2013b) and Chen and Jia (2016).Capital and labour are the two critical inputs in the production of desirable output such as gross domestic product (GDP) while energy consumption has also been deployed as the third input. In the process, undesirable outputs are produced and are treated as output in DEA analysis based on the assumption of weak disposability of output rather than being strongly disposable.The commonly used undesirable outputs are carbon dioxide (CO2), Nitrogen oxide(NOx), sulfur oxide (SO_X) and Methane.

Second, very few studies(Dyckhoff and Allen, 2001 and Yang et al, 2014) take undesirable output as input in the production process. This follows the argument that as much as firms seek to minimize the cost of inputs in the production process, they equally strive to minimize the production of pollutants. However, it has been argued that this approach only needs the information on whether the data hasto be minimized or maximized, but it cannot reflect the real productionprocess (Chen and Jia, 2016). In the third category, desirable and undesirable outputs are treated separately as output indicators to obtain the good efficiency and the bad efficiency respectively. Environmental efficiency is therefore obtained by finding the ratio of the good efficiency to bad efficiency (Färe et al, 2004; Zaim, 2004 and Halkosand Tzeremes, 2009). In this case, free disposability is assumed where the undesirable output can be reduced without changing the desirable output and the level of input while desirable output can be increased keeping pollutants and the level of input the same (Färe et al, 2004 and Watanabe and Tanaka, 2007).

2.3.2.3Second Stage (Regression) Analysis

The second stage entails the use of regression techniques for empirical analysis.Among these methods are Ordinary Least Square (OLS), General Methods of Moments (GMM), Two Stage Least Square (2SLS); Tobit model, and the various versions of Maximum Likelihood Estimator.The OLS is one of the most powerful and popular method of regression analysis. The method essentially seeks to minimize the sum of squares residuals (errors) such that the estimated parameters are as close to the true parameters as possible. OLS is most favourable in the presence of a number of assumptions (Gujarati, 2004). It assumes that the model to be estimated is linear in parameters while the values taken by the regressors, X, is fixed in repeated samples. It also assumes zero mean value of the disturbance term which is expected to be homoscedastic (equal variance) across all observations with zero correlation between the disturbances. Moreover, OLS may be appropriate where there is no problem of perfect multicolinearity while the model is correctly specified with zero covariance between the error term and explanatory variables. Given these assumptions, the OLS estimator is expected to have the minimum variance in the class of linear unbiased estimators. In explaining the role of trade in environmental efficiency,Taskin and Zaim (2001) employed panel OLS in their second stage analysis for the case of high, middle and low income countries while the same method is used bySong and Zhou (2015) and Honma (2015)for Chinese provinces and a group of 98 countries respectively. OLS is has also been used to analyses the effect of environmental efficiency (Doganay et al, 2014) and environmental regulation (van Beers and van den Bergh, 2000;Harris et al, 2002; Mulatu et al, 2004;Costantini and Crespi, 2008; Hering and

Poncet, 2014 and Li et al,2015) on international trade.The inability of OLS to produce efficient estimates where any of these assumptions are violated prompted the development of other methods that have been proved useful in the analysis of international trade.

Instrumental variable techniques such as 2 stage least square (2SLS) and generalized method of moments (GMM) have been variously employed to take care of these problems, especially in the presence of endogeneity that results in autocorrelation and contemporaneous correlation. Since GMM estimation was formalized by Hansen (1982), it has received wide interest in economics, including environmental analysis (Cole and Elliott, 2003 andDoganay et al, 2014). Unlike maximum likelihood estimation (MLE), GMM does not require complete knowledge of the distribution of the data and it can be computationally very easy.Moreover, in order to correct for possible dependent variable heteroscedasticity, Xu (2000) implemented the maximum likelihood technique to examine empirically whether more stringent domestic environmental policiesreduce the international competitiveness of environmentally sensitive goods (ESGs). Santos-Silva and Tenreyro (2006) propose a simple Poisson pseudo-maximum-likelihoodmethod (PPML) to address these problems. While estimating the impact of environmental policy on foreign trade, van Beers and van den Bergh (2000) noted that the use of a loglinear specification would require the elimination of zero flows whenestimating with ordinary least squares, which in turn would lead to biased estimates. They therefore used Tobit estimator and compared the results with those of OLS.These takes into account the chances that rounding off of small flows can yield zerotrade flows asvalueslower than US $100,000 may not be reported.

Recent methodological development has seen the introduction of count-data models, which are negative binomial pseudo maximum likelihood model (NBPMLM) and zero-inflated models-ZIM)(Baum, 2010). The strengths of these methods lie in their ability to capture the source of the zero counts. They are also less restrictive and do not require an instrument for the second stage of the regression. Also, unlike the Poisson regression that assumes equality between the mean and the variance of the distribution, the negative binomial regression allows the variance to differ from the mean.

This study identifies some gaps in the methodological literature where it seeks to make contribution. First, among the different pollutants that have been utilized in the existing studies, this study utilizes data on carbon emission as it is freely available for the case of Nigeria. Moreover, major environmental by-products from the various economic activities in Nigeria is carbon related. Examples of these activities include gas flaring (crude oil production), use of fossil fuel such as wood and waste, and fuel combustion from transportation, construction and manufacturing. Besides, according to Environmental Protection Agency (EPA, 2012) report, over 70% of the greenhouse gasemitted is carbon dioxide (CO2).

Following the possible adoption of carbon-efficient production technique that can maintain desirable output level from the given level of input while reducing the emission of pollutant, desirable and undesirable outputs can be treated separately as output indicators to obtain the good efficiency and the bad efficiency.This decomposition, which is hardly identified in the environmental efficiency-trade empirical literature, follows Halkos and Tzeremes (2009) who investigated the existence of a Kuznets type relationship between environmental efficiency and national income. Moreover, as this study utilizes multiple inputs without specifying any functional form, theSlack-based DEAapproach is employed in establishing the efficiency level of the countries of interest while adopting the count-data models (negative binomial pseudo maximum likelihood model-NBPMLM and zero- inflated models-ZIM)in the second stage, whose application in the bilateral trade-environmental efficiency link has been very limited.

2.3.3 Review of Empirical Literature

The literature is quite extensive on environmental related issues, especially those that focus on environmental efficiency. While some studies are particularly interested in establishing the level of environmental efficiency of production processes in various countries, others are concerned with either the determinants or implications of such efficiency. In particular, the role of international trade in environmental efficiency, as well as the trade effect of such efficiency, has been pointed out by several studies. Therefore, this section contains a review of (1) single-country studies on environmental efficiency,

(2) multi-country studies on environmental efficiency and (3) studies on international trade and environmental efficiency links.

2.3.3.1 Country-specific Studies on Environmental Efficiency Level

A number of country-specific studies have been conducted to investigate the level of environmental efficiencyacross regions. Such studies are particularly concentrated in Asia with overwhelming evidence from China where environmental efficiency of various sectors, as well as the aggregate economy, is examined. Apart from the many single-countrystudies conducted for the Asian region, such analysis has also been extendedto Australia (Azad and Ancev, 2014), Spain (Dios-Palomares and Martínez-Paz, 2011 and Aldanondo-Ochoa et al, 2014), Italy (Coli et al, 2011), the United States (Halkos and Tzeremes, 2013a) and the United Kingdom(Halkos and Tzeremes, 2013b).

For the Asian economies, single country studies appear to reach common conclusion that production processes are generally environmentally inefficient. For the case of China,Wang et al, (2014)investigated the twin objective of environmental efficiency and economic development in 2008 using meta-frontier and DEA. Their results indicated that overall environmental efficiency was low, especially when the most advanced production technology is selected as the reference.In the same vein, Song et al, (2013) calculated China'senvironmental efficiency on a regional basis using DEA and hierarchical cluster analysis during 1998-2009. They found that efficiency fell overtime in all four regions with the East having the highest efficiency score followed by the Northeast, the West and the Central in that order. Li et al (2020) subsequently reported that the southeast region of the country performs best in environmental efficiency the northwest region is worstbewteen 2015 and 2017. Also, measuring regional environmental efficiency in the same country, Li et al, (2013b)employed slack based measure-DEA (SBM-DEA) and reported that overall average level of environmental efficiency was low between 1991 and 2001, while large gap exists between the different provinces and areas.In a similar DEA analysis,Chen et al, (2014)revealed thatenvironmental efficiency was low, although average environmental efficiency was higher in the northwest China than in the east during 2001-2010.

Adopting similar method,Song et al, (2016) evaluated resource and environmental efficiency in 2011and found that only eight provinces in mainland China were environmentally efficient while 23 provinces are all environmental inefficient.Yang and Zhang (2016) used an extended DEA to investigate the dynamic trends of regional eco-efficiency inChina from 2003 to 2014. They found that, although economic efficiency is high, resource and environmental efficiencies are very poor. Their results further suggest that eastern and northern regions have experienced the greatest advances in both resource and environmental efficiency, while the undeveloped areas have not improved significantly.

On the contrary, very few studies submitted that aggregate environmental efficiency has been on the increase overtime in Asia. For instance, Wang et al, (2013) employed the Range-Adjusted Measure (RAM)-DEA to evaluate the regionalenergy and environmental efficiency of China. Their results indicated that average emission efficiency slightly increased during 2006–2010 while Li et al (2013a) reported continuous increase in environmental efficiency in Beijing during 2005-2009 in a similar analysis.Based on super-efficiency-DEA, Yang et al, (2014) evaluated regional environmental efficiencies in China and discovered regional disparities across 30 provinces between 2000 and 2010. Their results also revealed that east areas are generally more efficient in production, the west rank the last while central areas rank in between. Moreover, Zhang et al (2016) analyzed Chinese regional environmental efficiency utilizing data from 2005 to 2011. Their Slack based measure DEA results showed distinct difference among provincial administrative regions in China

A number of studies took sectoral perspective to the analysis of environmental efficiency of the Asian economy with similar mixed results. For instance, Chang et al (2013) analyzed the environmental efficiency of transportation industry in China in 2009 using non-radial DEA approach. Their results suggest that environmental efficiency of the industry is environmentally very inefficient with most provinces having efficiencies that are lower than 50% of the target level.Similarly, Wu et al (2015) measured the energy and environment performanceof Chinese transportation systems between 2011 and 2012. Applying parallel DEA approach, they showed thatoverall transportation system, as well as the two parallel subsystems, exhibited low environmental efficiency. For the same years, Song et al (2015b) combinedsuper-efficiency slack-basedmeasurewithwindow DEA tocalculateregionalenvironmental efficiencies ofhighwaytransportationsystemsin the same country. Overall level of environmental efficiency of this sector was found to besub-optimal, with great differencesbetween regions. However, Song et al (2015a) focused on railway transportation and showed evidence of slow increase in environmental efficiency overtime during 2006–2011with regional disparities. Their non-radial DEA results further showed that eastern area has the highest efficiency while the western area has the lowest.

In the energy sector, Du and Mao (2015) estimated theenvironmentalefficiency andmarginalCO2 abatement cost ofcoal-firedpowerplantsinChina in 2004 and 2008. Their parametric linear programming estimates indicated that average environmental efficiency in 2008 was slightly lower than that in 2004, which is an evidence of decreasing efficiency over the years. Moreover, Du et al (2016)conducted a similar analysis for the same country in 2008 and discovered that State-owned power plants were least efficient while 44% of total CO2 emissions can be cut if all power plants are completely efficient.Song and Zheng (2015) extended the analysisto the case of thermoelectric enterprisesin Anhui Province of China between 2009 and 2010. They found that overall level of environmental efficiencies of these enterprises is lower with great differences among the enterprises.In contrast to these findings, Zhou et al (2013) employed integrated non-radial DEA to assessed the power industry during 2005-2010 and found an increasing trend of environmental efficiency in China with marked differences among the provinces and fluctuating average levels of such efficiency.

Focusing onChinese industrial sectorfrom 2008 to 2012, Chen and Jia (2016) used DEA toshow that environmental efficiencies were generally low with larger differences in-between regions.Shao and Wang (2016) extendedthe analysis to the case of nonferrous metals industry between 2003 and 2009. Premise on estimates of Malmquist-DEA, they discovered thatenvironmental efficiency in the industry is highest in the eastern area of China. Wu et al (2014) grouped China into developed and less developed regions during 2007-2011 and evaluated environmental efficiency of the industrial sector. They submitted that economically developed provinces performed better in terms of environmental efficiency than the less developed provinces.Moreover, Goto et al (2014) compared the operational and environmental efficiencies of Japanese regional industries in 2002, 2005 and 2008. Their DEA estimates suggested that while environmental efficiency improved for manufacturing industries from 2002 to 2008, no significant improvement was observed in non-manufacturing industries. However, these findings differ from Xie et al, (2015) where DEA and Hierarchical Clustering methods are combined to analyze Chinese manufacturing industries. The study revealed that environmental efficiency remained low between 2001 and 2010.

Extending the analysis to the agricultural sector using the same technique, Kuo (2014) reveal that average efficiency score of the 58 villages in Taiwan was 43.12%.El Hanandeh and Gharaibeh (2016) assessed the environmental efficiency of olive oil production by small andmicro-scalefarmers in northern Jordan in a Monte Carlo Simulation performed in 2015. They reported that olive oil production in this region is more environmentally efficient than thelarge scale production practices found in other Mediterranean olive oil producing countries.

Findings are not significantly different in other regions where very few studies exist with much focus on comparative analysis. For US states,Halkos and Tzeremes (2013a)proposed a conditional directional distance function estimated through anextended Kuosmanen (2005) DEA to investigate the relationship between regional environmental efficiency and GDP per capita levels in 2005 and found that 11 out of 51 states are environmentally efficient. Using similar techniques for UK regions,Halkos and Tzeremes (2013b)measured regional environmental efficiency in 2007. Their results indicated that while 11 out of 37 regions are environmentally efficient, 11 others are most environmentally inefficient with average environmental inefficiency level of 0.37. Using DEA approach for the case of Spain, Dios-Palomares and Martínez-Paz (2011)studied the environmental impact of olive oil production process and foundmedium to high level of relative technical and environmental efficiency between 2005 and 2006.Also for the same country, Aldanondo-Ochoa et al, (2014)applied environmental efficiency model to the analysis of different vine production technologies in 2004. Adopting DEA and bootstrap techniques, they showed evidence of higher environmentally efficiency of organic agriculture relative to conventional agriculture in dryland farming. Azad and Ancev (2014)measured environmental efficiency of agricultural water use in Australia utilizingLuenberger environmental indicator and revealed substantial variation in environmental performance of irrigation enterprises across the regions.Coli et al, (2011) focused on environmental efficiency of Italian provinces in 2004 and submitted, using DEA, that North-East showed higher average efficiency scoreand lessvariability than other groups. Their results further suggested differences in environmental efficiency among Southern and Northern provinces.

The literature reveals that country-specific analysis of environmental efficiency largely concentrated on the Asian economies with about 70% of the studies focusing on China. Such analysis has equally been conducted for some European economies (United Kingdom, Spain and Italy) and Australia. There appear to be overwhelming evidences that production processes in Asia (particularly China) are generally environmentally inefficient, though very few studies argue otherwise. However, there seems to be a consensus on the regional disparity in environmental efficiency across regions and provinces, with East China exhibiting high relative efficiency. Moreover, transportation and manufacturing activities in Asia have been reported to be associated with low environmental efficiency with mixed results for agriculture. In addition, while country-specific studies focus on regional or province-based analysis, very few studies are conducted at firm-level which may be a result of data constraint as most firms do not report the environmental implication of their activities.[23]

In the United Kingdom, environmental efficiency seems to be generally low, while such efficiency tends to vary across Italian provinces. In Spain, agricultural production processes could exhibit varying environmental efficiency (from medium to high) depending on the type of farm practices while this variation exist among irrigation enterprises across Australian regions.Table 2.12 presents the summary of country-specific studies on environmental efficiency level.

[23]Most firms may fail to report the level of environmental pollution associated with their activities if they are not compelled to do so given the additional cost on them. This may explain the dominance of macro data analysis of environmental issues in the literature both at single country and multi-country levels.

Table 2.12.Summary of Country-specificStudies on Environmental Efficiency

S/N	Author & Year	Country/Sector & scope	Methodology			Findings
			Input Variables	Output Variables	Estimation methods	
1	Song et al, (2016)	China/agg (2011)	EL and K	W, EG and Y	Improved SBM-DEA	Only eight provinces in mainland China are environmentally efficient while 23 provinces are all environmental inefficient
2	Chen and Jia (2016)	China/Industry (2008-2012)	Lb, C and EC	SO2, W and Y	SMB-DEA	EFs are generally low withlarger differences in between regions.
3	Chen et al, (2014)	China/agg (2001-2010)	EC and K	W and Y	Traditional DEA	EF was low with average EF higher in the northwest China than in the east.
4	Du et al, (2016)	China/power (2008)	K, Lb and EC	EL and CO2	Parametric directional distance functions	State-owned power plants are least efficient relative to the meta-frontier while 44% of total CO2 emissions can be cut if all power plants are completely efficient.
5	Du and Mao (2015)	China/power (2004 and 2008)	K, Lb and EC	EL and CO2	parametric LP	The average environmental efficiency in 2008 was slightly lower than that in 2004
6	Li et al, (2013a)	Beijing /agg (2005-2009)	Various pollutants	Y	Adjusted conventional DEA	EF of Beijing continued to increase during 2005-2009
7	Li et al, (2013b)	China/agg (1991–2001)	Lb, K and T	Y and W	Super SBM-DEA	Overall average level of EF is low, and the gap between different provinces and areas is large.
8	Song et al, (2013)	China/agg (1998–2009)	Lb, K and EC	W and Y	DEA and HCA	Efficiency fell overtime in all four regions with the East having the highest efficiency score followed by the Northeast, the West and the Central in that order
9	Shao and Wang (2016)	China/Industry (2003-2009)	EC and total assets	Y, sales and CO2	Malmquist-DEA	The industry's environmental efficiency is highest in the east area.
10	Song and Zheng (2015)	China/thermoelectric enterprises (2009-2010)	CL, PT, WC and EL	W, COD, ELT, Y and ST	Malmquist-DEA	Overall level of environmental efficiencies of thermoelectric enterprises in Anhui Province is lower with great differences among the enterprises.
11	Song et al, (2015a)	Chinese regions/ agg (2006–2011)	Lb, K and EC	Y, CO2 and SO2	non-radial DEA	EF slowly increased overtime with regional disparities. The eastern area has the highest EF and the western area has the lowest.
12	Song et al, (2015b)	China/transportation (2011-2012)	HM, Lb and EC	NO2, PM, LEQ, PS and FR	Super- efficiency SBM and window DEA	Overall level of EF of highway transportation systems was not optimal, with great differences between regions.
13	Chang et al (2014)	China/Transportation	K, Lb and EC	Y and CO2	Non-radial DEA	Transportationindustryis environmentallyveryinefficient.
14	Wang et al, (2013)	Chinese regions/agg (2006–2010)	Lb, K and EC	Y and CO2	RAM-DEA	Average emission efficiency slightly increased.
15	Wu et al, (2014)	Chinese regions/industry (2007–2011)	K and EC	Y and NO2	Fixed sum output DEA	Economically developed provinces have better EF than less developed provinces
16	Xie et al (2015)	China/manufacturing (2001-2010)	Lb and K	W	DEA	EF remains low
17	Wang et al, (2014)	China/agg (2008)	Lb, K and EC	Y and SO2	DEA	Overall EF is low when the most advanced production technology is selected as the reference.
18	Zhou et al, (2013)	China/Power industry (2005–2010)	Lb, K and EC	EL, SO2, CO2 and Nox	Integratednon-radial DEA	A marked difference in EF of the power industry among Chinese provinces. While annual average EF level fluctuates, there is an increasing trend.
19	Wu et al, (2015)	China/transportation (2011-2012)	PST, M, CT, Lb, K and EC	CO2, PS and FR	Parallel DEA	Low EF in the transportation system and the two parallel subsystems
20	Yang et al, (2014)	China/agg (2000-2010)	CI2, SO2, Lb, K and EC	Y	Super-efficiency DEA	Regional disparities in EF across 30 provinces. East areas are more efficient in production, the west rank the last while central areas rank in between
21	Chang (2014)	China/agg (2005-2011)	Lb, K and EC	CO2, SO2, COD and Y	SBM-DEA	Distinct difference in provincial administrative regions (PARs)
22	Yang and Zhang (2016)	China/agg (2003 to 2014)	Lb, K, L, WT and EC	Y, W, HR, W, dust and SO2	Bootstrapping DEA	Economic efficiency is high but resource and environmental performances on EF are not encouraging. The eastern and northern regions have experienced the greatest advances in both resource and EF, while the undeveloped areas have not shown much progress.
23	El Hanandeh	Jordan/agriculture (2015)	Various		Monte Carlo	Olive oil production in the northern region of Jordan is environmentally efficient

	and4Gharaibeh (2016)				Simulation	relative to large scale production practices common in other Mediterranean olive oil producing countries
24	Kuo (2014)	Taiwan/agriculture (2005)	H, FA and E	Y, P and Pol	DEA with undesirable output	Average efficiency score of the 58 villages was 43.12%
25	Goto et al, (2014)	Japan/industry (2002, 2005 and 2008)	Lb, K and EC	Y, CO2, NOx, SOx and dust	Non-radial DEA	EF improved for manufacturing industries from 2002 to 2008 but not for non-manufacturing industries
26	Azad and Ancev (2014)	Australia/agriculture ()	IW and other cost	Rev, WWI and SI	Luenberger environmental indicator	Substantial variation in environmental performance of irrigation enterprises across the regions.
27	Aldanondo-Ochoa et al, (2014)	Spain/agriculture (2004)	Lb, L and other inputs	Nitrogen Surplus and pesticide toxicity index	DEA and bootstrap techniques	Organic agriculture is more environmentally efficient than conventional agriculture in dryland farming
28	Dios-Palomares and Martínez-Paz (2011)	Spain/agriculture (2005-2006)	K, Lb and OM	QI, EMI and OP	DEA	Medium–high level of relative technical and environmental efficiency
29	Coli et al, (2011)	Italy/agg (2004)	EH	NO2, PM10 and Y	DEA	North-East shows a higher average efficiency score (0.7972) and lessvariability than other groups. Also, there are differences in environmental efficiency among Southern and Northern Italy provinces.
30	Halkos and Tzeremes (2013a)	US regions/agg (2005)	Lb and K	Y and CO2	Extended Kuosmanen (2005)DEA	11 out of 51 states are reported to be environmentally efficient
31	Halkos and Tzeremes (2013b)	UK regions/agg (2007)	Lb and K	Y, CO2, methane (CH4) and nitrous oxide (N2O)	DEA	Average environmental inefficiency level is 0.37. While 11out of 37 regions are environmentally efficient, 11 others are most environmentally inefficient

Note: TL = Trade liberalisation; Y2 = Square of GDP; Y = GDP (growth); FD = Financial development; CO2 = Carbon emission; D = Distance; W = Weight; EF = Environmental efficiency index; POP = Population; L = Land; X = Export; M = Import; C = contiguity, LN = common language; CL = common colony; OLS = Ordinary least square; ECM = Error correction mechanism; GMM = generalized methods of moments; EC = Energy consumption; F = Finance/Financial performance; EID = Environmental international diversification; PES = Proactive environmental strategy; FZ = Firm size; EX = Export experience; OLC = Organizational learning capability; T = trade (flow) openness; Lb = Labour; K = Capital; ER = Environmental regulation; CI = Coal intensity; CO = Coal consumption; EI = Total energy intensity; ELI = electricity intensity; KI = Capital intensity; AV = Air Visibility; P = Polity; ED = Export product diversification; ARDL = Autoregressive distributed lag model; R&D = Research and development; PA = Pollution abatement cost; 2SLS = Two stage least square; ESGs = environmentally sensitive goods; PPML = Poisson pseudo-maximum-likelihood method.

2.3.3.2Cross-country Studies on Environmental Efficiency Level

Cross-country analysis showed inconsistent results which may be due to differences in country and regional characteristics and/or econometric technique. For instance, Ewertowska et al (2016) combined the Life Cycle Assessment (LCA) and DEA to analyze the environmental performance of the electricity mix of top European economies in 2012 and showed that 19 (73%) of the 26 countries are environmentally efficient.Moreover, Kounetas (2015) measured technology(TG)andenvironmentalefficiency technologygaps(EETGs)in25European countries in 2002 and 2008. Using directional distance function, his results indicated that environmental efficiency performance of European countries seems to increase on average during 2008 compared to 2002. Based on non-radial DEA analysis of the EU+2 countries,Vlontzos et al (2014) evaluated the energy and environmental efficiency of the primary sectors between 2001 and 2008. Their results suggest that Eastern European countries achieved low efficiency scores while environmental efficiencyimproved in UK, Portugal, Germany, Austria, Poland, Lithuania, and Latvia. They also found that Denmark, Spain, Netherlands, Italy, Belgium and Bulgaria are the leaders in terms of environmental efficiency.

In the East Asia shipping industry, Chin and Low (2010)investigated the implication of production efficiencyon environmental efficiency in 2009 and discovered that technically efficient shipping tends to achieve environmental efficiency while environmental efficiency is high in the production of shipping services. Using the Theil coefficient, Abdallah et al (2015),provided an international comparison of the energy intensity and the carbon dioxideintensity in the road transport sector for a group of 90 countries during 1980-2012. Their results suggest the existence of inverse relationship between energy efficiency and environmental efficiency with spatial and temporal disparities across countries.Lee et al (2014) assessed the environmental efficiency of port cities among the world top 27 ports in 2011. Utilizing the SBM-DEA technique,they found that the most environmentally efficient port cities are Singapore, Busan, Rotterdam, Kaohsiung, Antwerp and New York, while Tianjin is the least environmentally efficient.Employing the same technique, Chang (2014) considered 27 global airlines in 2010 and revealed that Asia-based airlines are generally more environmentally efficient, followed by European and American airlines.

Focusing on Organization for Economic Corporation and Development (OECD) countries, Yörük and Zaim (2006)constructed an environmental efficiency index for 27member countriesbefore examining the relationship between environmental efficiency andincome using the environmental Kuznets curve (EKC)framework. Their DEA scores suggest that Poland, Hungary, and Luxembourg are the three best performers in terms of environmental efficiency amongthe OECD countries, while Italy, Mexico, and Switzerland are ranked the three worst between 1983 and 1998.However,Halkos and Tzeremes (2009) examined the existence of a Kuznets type relationship between countries' environmental efficiency and national income among 17 OECD countries during 1980–2002. Their DEA window analysis indicate that countries with higher environmental efficiency are Japan, Austria, the Netherlands, Sweden and Denmark while such efficiency in the UK, Greece, Spain, Australia and Canada islow .Using 31 OECD countries in a Malmquist-DEA analysis, Woo et al, (2015)studied the environmental efficiency of renewable energy from the static and the dynamic perspective from 2004 to 2011.They found existence of geographical differences in environmental efficiency across OECD with the highest averageexisting in OECD America while those in Europe have the largest standard deviation.

Furthermore, Valadkhani et al, (2016) measured efficiency changes among the 46 world major polluters from 2002 to 2007 and 2011 using multiplicative environmental DEA. Their results indicated that efficiency scores increased over this period for most countries. The results further show that environmental efficiency cannot be realized without first reaching a certain threshold of economic efficiency. Lin et al (2013) adopted stochastic frontier method for a group of 63 countries during 1981-2005. They showed evidence of highest average environmental efficiency among high income countries while lower-middle income and low income countries recorded negative growth in average in such efficiency.In a similar study, Li and Wang (2014) extended the analysis to a group of 95 countries during 1996-2007. Their global and meta-frontier SBM-DEA estimates confirm the existence of increasing environmental efficiencies among high and upper middle-income countries with those in lower middle- and low-income countries showing decreasing trend.Tateishi et al (2020) employed Stochastic Frontier Analysis with a by-production approach among 116 countries, and found that countries with high institutional quality have environmental efficiencies that are close to the frontier. Sun et al (2020) use Malmquist total factor productivity index toshow that average global environmentalefficiency grewby about 1.3% during 1980-2016, with convergence conditionalon industrial structure, globalization, and energy price.

Cross-country evidences of environmental efficiency are few. Notwithstanding, studies have shown that environmental efficiency has generally improved over the recent years in Europe, especially in the UK, Portugal, Germany, Austria, Poland, Lithuania, and Latvia. Also, countries in OECD America recorded high environmental efficiency while such efficiency is gradually improving among the world polluting countries in recent years. However, while environmental efficiency levels are high in high income countries, they are generally low in low income countries.Also, as observed in the case of single-country studies, macro level data is utilized across all studies that conducted cross-country analysis.Table 2.13 shows the summary of cross-country studies on environmental efficiency level.

Table 2.13. Summary of Cross-country Studies on Environmental Efficiency

S/N	Author & Year	Country/Sector & scope	Methodology			Findings
			Input Variables	Output Variables	Estimation methods	
1	Ewertowska et al (2016)	Top 27 European economies/power (2012)	15 different Pollutant	EL	DEA	After removing outlier (Norway), 7 eco-inefficient countries out of 26
2	Kounetas (2015)	25 European countries/agg (2002 and 2008)	Lb, K and EC	CO2 and Y	DDF	Environmental efficiency performance of European countries seems to increase on average during 2008 compared to 2002
3	Vlontzos et al (2014)	EU countries/agg (2001-2008)	Lb, K and EC	Y and CO2	Non-radial DEA	Eastern European countries achieve low efficiency scores. EF has improved in UK, Portugal, Germany, Austria, Poland, Lithuania, and Latvia. Denmark, Spain, Netherlands, Italy, Belgium and Bulgaria are on the frontier
4	Chin and Low (2010)	East Asia/transport (2009)	FSS and BTF	CCF, NOx, SO2, CO2 and PM	DEA	EF is high in productionof port services across East Asia
5	Yörük and Zaim (2006)	OECD countries/agg (1983-1998)	Lb and K	Y, CO2 and W	DEA	Poland, Hungary, and Luxembourg are the three best performers among the OECD countries, while Italy, Mexico, and Switzerland are ranked the three worst
6	Woo et al (2015)	31 OECD countries/agg (2004-2011)	Lb, K and RES	EL, CO2 and Y	Malmquist-DEA	Geographical differences in EF across OECD. Countries in OECD America have the highest average EF while those in Europe have the largest standard deviation.
	Halkosand Tzeremes (2009)	17 OECD (1980–2002)	Lb and K	SO2 and Y	DEA window analysis	Countries with higher EF are Japan, Austria, the Netherlands, Sweden and Denmark. Countries with lower EF scores are reported to be theUK, Greece, Spain, Australia and Canada.
7	Valadkhani et al (2016)	46 world major polluters/agg (2002, 2007 and 2011)	Lb, K and EC	Y, CO2, NO2 and Methane	Multiplicative environmental DEA	For most countries, efficiency scores increased over this period. EF cannot be realized without first reaching a certain threshold of economic efficiency
8	Lee et al (2014)	World top 27 ports/transportation (2011)	Lb	Y, CO2, SO2, NOx	SBM-DEA	Singapore, Busan, Rotterdam, Kaohsiung, Antwerp, and New York are the most EF port cities, while Tianjin is the least environmentally efficient.
9	Chang (2014)	27 global airlines (2010)	EC, K and Lb	CO2, Rev and Pr	SBM-DEA	Asia-based airlines are generally more environmentally efficient, followed by European and American airlines
10	Abdallah et al (2015)	90 countries/transport (1980-2012)	EI, CO2, Y and EC		Theil coefficient	Inverse relationship between energy efficiency and environmental efficiency with spatial and temporal disparities in environmental efficiency across countries.
11	Lin et al (2013)	63 countries/agg (1981-2005)	L, K and EC	CO2 and Y	Stochastic frontier	High income countries have the highest average EF, while lower-middle income and low income countries recorded negative growth in average EF.
12	Li and Wang (2014)	95 countries/agg (1996-2007)	K, Lb and EC	CO2 and Y	Global and meta frontier SBM-DEA	EFs in high- and upper middle-income countries showed increasing trend while those in lower middle- and low-income countries showed decreasing trend.

Note: TL = Trade liberalisation; Y2 = Square of GDP; Y = GDP (growth); FD = Financial development; CO2 = Carbon emission; D = Distance; W = Weight; EF = Environmental efficiency index; POP = Population; L = Land; X = Export; M = Import; C = contiguity, LN = common language; CL = common colony; OLS = Ordinary least square; ECM = Error correction mechanism; GMM = generalized methods of moments; EC = Energy consumption; F = Finance/Financial performance; EID = Environmental international diversification; PES = Proactive environmental strategy; FZ = Firm size; EX = Export experience; OLC = Organizational learning capability; T = trade (flow) openness; Lb = Labour; K = Capital; ER = Environmental regulation; CI = Coal intensity; CO = Coal consumption; EI = Total energy intensity; ELI = electricity intensity; KI = Capital intensity; AV = Air Visibility; P = Polity; ED = Export product diversification; ARDL = Autoregressive distributed lag model; R&D = Research and development; PA = Pollution abatement cost; 2SLS = Two stage least square; ESGs = environmentally sensitive goods; PPML = Poisson pseudo-maximum-likelihood method.

2.3.3.3Studies on International Trade and Environmental Efficiency Link

The link between international trade and environmental quality, as well as environmental regulation and strategies, has been variously investigated.These studies often establish the environmental efficiency level before determining such link in a multiple stage analysis. The literature in this regard has largely concentrated on cross country analysis with very few studies (Shahbaz et al, 2013;Michieka et al, 2013; Hering and Poncet, 2014;Song and Zhou; 2015 and Gozgor and Can, 2016) conducted for single countries.

Several authors argued that international trade and trade related regulations are important sources of environmental quality. On this account, Michieka et al, (2013)employed Toda and Yamamoto Granger causality to analyze data spanning 1970 to 2010for China and found that causality runs from exports to emissions. Consequently, Li et al (2015) employed panel OLS to determine the effect of trade openness on environmental quality among 134 countries between 1961 and 2004, reporting a significantly negative impact of trade openness on air quality. Also, simulation results ofCristea et al (2013) showed thatinternational transport is responsible for 33% of world-wide trade-related emissions in a group of 113 Countries in 2004. They further discovered that as trade shifts toward distant trading partners, full liberalization of tariffs, as well as GDP growth leads to transport emissions growing much faster than the value of trade.In the same vein, Ertugrul et al, (2016) examined the relationship among CO2 emissions, trade openness, real income and energy consumption top ten CO2 emitters in developing economies from 1971 to 2011. ARDL estimates reveal that trade openness has increasing effect on carbon emissions in the long run.

In the particular case of Turkey, Gozgor and Can (2016) investigated the relationship between export product diversification and the Environmental Kuznets Curve during 1971-2010 using dynamic OLS and ECM. Their results suggest that the greater the level of export product diversification, the higher CO2 emissions in the long run.Taskin and Zaim (2001) investigated the role of trade on the changes in environmental efficiency betweenhigh andlow and middle income countries between1977 and 1990.Their panel OLSresults indicate that trade has significant impact on environmental efficiency, though the effect varied from high income to low and middle income countries, as well as by sector. Particularly, they reported that while service export increased carbon emission, export of manufactures reduced it in both groups of countries.

In the case of China, Song and Zhou (2015)studied the relationships among trade, the economy, and environmental qualityfrom 2003 to 2012.Using panel OLS in the second stage analysis, they found thatimport hadexerted increasing effect on environmental efficiency, though the effect of export was negative. Hence, the reducing effect of trade on environmental pollution has become prominent in the literature. Among OECD countries, Erdogan (2014) adopted the general equilibrium model and found that full trade liberalizations help to lower OECD pollution emissions by 32% in the year 2000, and about half of the decline in pollution is due to international productivity differences. Similarly, ARDL results of Shahbaz et al, (2013)provided evidence of reducing impact of trade openness on carbon emission in Indonesia during 1975–2011.These findings are consistent with those of Dogan and Seker (2016) where fully modified OLS and dynamic OLS is used to analyze 23 of the 40 countries listed in the Renewable Energy Country Attractiveness Index during 1985-2011.Adewuyi and Awodumi (2021) extended the analysis to petroleum import, carbon emission and economic growth in Nigeria and South Africa using simultaneous equations. Findings show significant negative feedback effect between petroleum import and carbon emission in Nigeria.

In the East Asia, Zhang (2015) investigated the effect of international production fragmentation-induced intermediate goods trade on the link between energy consumption and carbon pollution between 1998 and 2011. Using panel OLS with fixed effects in their second stage analysis, they submitted that intermediate goods trade contributes to a greater decrease in carbon pollution.Adopting similar techniques, Honma (2015) assessed the impact of international trade on environmental efficiency among 98 countries utilizing data from 1970 to 2008. Estimates reveal that the benefit of trade on the environmental efficiency is greater with higher relative income per capita.

Rather than the effect of trade on environment, a number of studies emphasized the role of environmental quality and regulation in international trade in an attempt to improve world trade. Irrespective of scope, these studiespresent two strands of the literaturein this regard.One strand of the literature argues that environmental standards would contribute positively to firm competitiveness in the international market byencouraging innovations and improving efficiency.On this Account, Doganay et al, (2014) investigated the impact of environmental efficiency on international trade among 111 countries during 1980-2009.Having determined the environmental efficiency of each country, their ordinary least square (OLS) and general methods of moments (GMM)estimates revealed that environmental efficiencyhave strong positive effects on both exports and imports. Similarly, Costantini and Crespi (2008)studied the effect of environmental regulation on the export dynamics of energy technologies for renewable energies among 20 exporting and 148 importing countries between 1996 and 2005.Using Panel OLS, they discovered that environmental regulation has significant positive effect on such exports. For the case of 14 OECD countries, van Beers and van den Bergh (2000) employed Tobit and OLS technique to assess the impact of environmental policy on foreign trade and reported that strict environmental policy has positive effect on total exports, though the effect on dirty trade is negligible.

Another strand of the literature provides evidence that environmental efficiency may hinder international competitiveness due to green protectionism. Hering and Poncet (2014) investigated the effectiveness of environmental policy on exports in China. Estimates from panel OLStechnique revealthat stricter regulations on sulfur di oxide (SO_2) emissions reduced sectoral exports during 1997-2003, especially for more polluting industries.Using similar methods, Harris et al, (2002) studied the impact of environmental policy on bilateral foreign trade flows among 24 OECD countries between 1990 and 1996. They showed that relative strictness of environmental regulation in the importing country has strong significant negative effect on total bilateral import flows, while the regulations in the exporting country seem to be negligible.

A few studies also accounted for ‘dirty’ and environmentally-sensitive goods and emphasize the declining impact of environmental regulation. For instance, Mulatu et al (2004) adopting panel OLS in a similar analysis of manufacturing industries in Germany, Netherlands and USA. Theysubmitted that trade pattern differs across countries and industries depending jointly on relative factor endowments and environmental stringency differential. In particular, they found that stringency of environmental regulation in the

U.S. is a source of comparative disadvantage in dirty industries. This result is also reported to be true for pollution intensive industries in Germany. For Netherlands, however,there is evidence of this negative link in the wood and fabricated metal industries only when allowing for sectorial variation.Cole and Elliott (2003) assessed the impact of environmental regulations on trade patterns among 60 developed and developing economies in 1995. Their two stage least square estimates indicate that environmental regulation has no significant impact on dirty goods exports. However, Xu (2000) used maximum likelihood method to show that more stringent environmental regulation does not reduce total exports, exports of environmentally sensitive goods (ESGs) and exports of non-resource-based environmentally sensitive goods (ESGs) among 20 Countries in 1990.

Review of relevant literature on the links between environmental quality and international trade has been analyzed mostly at cross-country level, with findings that are largely inconsistent. While most studies focused on the analysis of drivers of environmental quality, a few others are concerned with the specific role of environmental regulation in international trade. In Asia, the only study identified in this regard (Hering and Poncet, 2014) submitted that environmental regulation hinders export. These findings have also been reported for dirty and pollution intensive industries in Germany, Netherlands and USA. However, there appears to be negligible impact of environmental regulation on export of dirty goods among OECD countries, but positive impact on total export and negative effect on total bilateral import flows. Findings of other cross-country studies have been mixed which may be due to varying country characteristics as well as methodology.Table 2.14 provides a summary of literature on international trade and environmental efficiency

The literature on environmental efficiency is relatively recent and progressing.Studies in this regard have been conducted in many countries across different regions of the world with particular concentration in Asia. Despite the existence of large body of studies in the literature and continuing interest on environmental efficiency, a number of gaps still exist. First, there is a dearth of studies in this regard in Africa, and Nigeria in particular.Second, even among the existing studies, much effort was directed toward understanding environmental efficiency level while a few others further provided a role for income.

Third, most studies linking environmental quality with trade focus on environmental regulation while few others are concerned with the impact of trade on environmental efficiency (Taskin and Zaim, 2001; Honma, 2015, and Song and Zhou, 2015).Doganay et al, (2014) appears to be the only study that investigated the impact of environmental efficiency on bilateral trade. However, this study was conducted for 111 countries with little policy implication for the individual countries involved in bilateral trade relation. Also, they only considered aggregate bilateral trade flows which make it difficult to understand the sector that is mostly affected by environmental efficiency, hence sectoral conclusions are missing.The present study provides a role for environmental efficiency in both aggregate and sectoral bilateral trade between Nigeria and her top trading partners in Asia and the EU.

Table 2.14. Summary of Literature on International Trade and Environmental Efficiency

S/N	Author& Year	Country (s) & scope	Methodology		Findings
			Variables	Estimation methods	
1	Cristea et al (2013)	113 Countries (2004)	TL, Y, D, W and CO2	Simulation	International transport is responsible for 33 % world-wide trade-related emissions. Full liberalization of tariffs and GDP growth lead to transport emissions growing much faster than the value of trade, due to trade shifting toward distant trading partners
2	Doganay et al (2014)	111 countries (1980-2009)	EF, X, Y, POP, L, D, C, LN and CL	DEA, OLS,PPMLand GMM	Environmental efficiency has strong positive effects on both exports and imports.
3	Song and Zhou (2015)	China (2003 to 2012)	EF, M, X, POP, Y, EC and F	DEA and Panel OLS	Export and import have negative and positive effect on environmental efficiency respectively
4	Honma (2015)	98 countries (1970–2008)	EF, Y, L, K, T, CO2, SO2, NOx and PM10	DEA and Panel OLS	The higher the relative income per capita, the more the benefit of trade on the environmental efficiency
5	Taskin and Zaim (2001)	High,low and middle incomecountries (1977-1990)	EF, Y, CO2, L, K, PX, X and T	DEA and Panel OLS	Trade is important for environmental efficiency
6	Costantini and Crespi (2008)	20 exporting and 148 importing countries (1996-2005)	Various	Panel OLS	Environmental regulation has significant positive effect on exports
7	Erdogan (2014)	OECD (2000)	Various	General equilibrium model	Full trade liberalizations help to lower OECD pollution emissions by 32%, and about half of the decline in pollution is due to international productivity differences
8	Hering and Poncet (2014)	China (1997-2003)	ER, SO2, CI, EI and ELI, KI and X	Panel OLS	Stricter regulations on sulfur di oxide (SO2) emissions reducedsectoral exports especially for more polluting industries
9	Li et al (2015)	134 countries (1961–2004)	T, AV, L, P and Y	Panel OLS	Significantly negative impact of trade openness on air quality
10	Michieka et al (2013)	China (1970–2010)	X, T, CO2 and CO	Toda and Yamamoto Granger causality	Granger causality runs from exports to emissions
11	Gozgor and Can (2016)	Turkey (1971-2010)	Y, Y2, ED and EC	Dynamic OLS and ECM	Greater export product diversification yields higher CO2 emissions in the long run
12	Shahbaz et al (2013)	Indonesia (1975–2011)	FD, Y, EC, T and CO2	ARDL	Trade openness reduces CO2 emission
13	Dogan and Seker (2016)	23 countries in the Renewable Energy Country Attractiveness Index (1985-2011)	Y, EC, T, FD and CO2	Fully modified OLS and Dynamic OLS	Trade openness and financial development decrease carbon emissions
14	Ertugrul et al (2016)	Top ten CO2 emitters among the developing countries (1971-2011)	T, Y, EC and CO2	ARDL	Trade openness is a major determinant of carbon emissions in the long run
15	Zhang (2015)	East Asia (1998–2011)	Y, EC, X, M, EC	Panel OLS with fixed effects	Intermediate goods trade contributes to a greater decrease in carbon pollution
16	Mulatu et al (2004)	Germany, Netherlands and USA (1977-1992)	X, M, Y, K, PA, R&D and L	Panel OLS with pooled and fixed effect	Trade pattern differs across countries and industries. Trade pattern in dirty manufactured commodities is jointly determined by relative factor endowments and environmental stringency differential
17	van Beers and van den Bergh (2000)	14 OECD countries	T, POP, D, Y, L and ER	Tobit and OLS	Strict environmental policy has no significant effects for dirty trade while the effect on total exports is positive
18	Cole and Elliott (2003)	60 developed and developing economies (1995)	ER, Lb, K, Y and various natural resources	2SLS	Environmental regulation has no significant impact on dirty goods exports
19	Harris et al (2002)	24 OECD countries (1990–1996)	Y, POP, D, L, ER, EC and M	Panel OLS	Relative strictness of ER in the importing country has a strongly significant negative effect on total bilateral import flows, while the regulations in the exporting country seem to be uninfluential
20	Xu (2000)	20 Countries (1990)	Bilateral X, Y, POP, D, ER and import tariffs.	Maximum likelihood	More stringent ER does not reduce total exports, exports of ESGs and exports of non-resource-based ESGs

Note: TL = Trade liberalisation; Y2 = Square of GDP; Y = GDP (growth); FD = Financial development; CO2 = Carbon emission; D = Distance; W = Weight; EF = Environmental efficiency index; POP = Population; L = Land; X = Export; M = Import; C = contiguity, LN = common language; CL = common colony; OLS = Ordinary least square; ECM = Error correction mechanism; GMM = generalized methods of moments; EC = Energy consumption; F = Finance/Financial performance; EID = Environmental international diversification; PES = Proactive environmental strategy; FZ = Firm size; EX = Export experience; OLC = Organizational learning capability; T = trade (flow) openness; Lb = Labour; K = Capital; ER = Environmental regulation; CI = Coal intensity; CO = Coal consumption; EI = Total energy intensity;ELI = electricity intensity; KI = Capital intensity; AV = Air Visibility; P = Polity; ED = Export product diversification; ARDL = Autoregressive distributed lag model; R&D = Research and development; PA = Pollution abatement cost; 2SLS = Two stage least square; ESGs = environmentally sensitive goods; PPML = Poisson pseudo-maximum-likelihood method.

CHAPTER THREE

THEORETICAL FRAMEWORK AND METHODOLOGY

3.1 Introduction

This chapter contains the theoretical framework and methodology for this study. It starts with a discussion of the theoretical explanation of the link between environmental efficiency and bilateral trade. The chapter thereafter presents the methodology of the study.

3.2 Theoretical Framework

This study extends the neo-classical trade theory, particularly theHeckscher-Ohlin (H-O)modelby incorporating the role of environmental efficiency (as a form of trade distortion) in bilateral trade. This will facilitate the determination of the impact of environmental efficiency on trade between Nigeria and its top trading partners. This extension is consistent with the earlier studies such as Kohn (2000) and Markusen et al (1995) where H-O model was expanded or modified to account for environmental tax and government (environmental) policy respectively.

The standard H-O model states that production techniques areidentical between trading partners, while their factor endowments differ. The implication of this is that each partner has capacity to produce what her factor endowment could support based on comparative advantage. This outcome is made possible in the presence of a number of assumptions such as constant returns to scale, identical and homogenous preferences between the trading partners and perfect competition (Markusen et al, 1995). Thus, the H-O model suggests that, in the absence of market distortions, each partner has the ability to produce for export the product that intensively uses the relatively abundant resources and import the good that uses the relatively scare factor intensively. However, it could be argued that trade is not truly free due to the presence of associated trade costs disguised as non-tariff or technical trade barriers such as environmental standards including efficiency standard (Esty, 2001 and Doganay et al, 2014).

For resource-rich developing economies, including Nigeria, the autarky relative price of commodity produced from the abundant resource is lower than what obtains in the resource-scarce partner economy.Production activities in the natural resource as well as the consumer and industrial goods sectors, require the input of energy to facilitate the operation of critical inputs such as labour and capital (Adewuyi and Awodumi, 2017)[24]. Energy consumption, especially from refined petroleum products, aids the provision of conducive environment through heating, cooling and lightning which enhances the functioning of (skilled) labour. Also, the huge machinery and equipment used in the production process are powered by refined petroleum products. These processes generate large amount of carbon and related emissions into the environment which are major sources of greenhouse gas (GHG). Besides, in oil rich developing economies, environmental degradation resulting from oil spillage and gas flaring are common characteristics of oil production and export. In resource-scarce developed economies where capital is relatively abundant, efforts are largely directed towards the industrial sector producing and exporting consumer and industrial goods in large quantities. Like the oil sector, energy consumption is equally high in this sector, underscoring the high level of carbon and related emissions in the industrial economies, necessitating the call on these economies to make efforts to reduce such emissions[25].

Following global environmental concerns, governments have devised policies and regulations that allow producers to adopt environmentally-efficient production techniques in order tominimize environmental pollution from consumption and production (Ozcan, 2013).The level of compliance and effectiveness of such environmental regulations and policies is reflected in the resulting level of environmental efficiency in the economy.Given the existing H-O framework of bilateral trade and assuming the presence of a social planner who enforces a regulation to reduce environmental pollution, such regulation could take the form of consumption or production tax(Markusen et al, 1995) as shown in Figure 3.1. Consumption tax is imposed on consumption goods especially high carbon emitting items such as fossil fuel using vehicles and generators as well as

[24]In the developing economies, capital required for the production of crude oil or other natural resources are largely acquired through foreign investment (Nunnenkamp, 2002 and Asiedu, 2013)
[25]Kyoto protocol of 1997 tasks the industrialized economies to variously reduce greenhouse gas (Shahbaz et al, 2013).

firewood. Such tax potentially reduces consumers' disposable income which could reduce consumption of such items. Consequently, consumers are forced to switch to less carbon-emitting goods (such as electric and solar automobiles) which largely come from abroad and hence increase import. In most of the EU+2 countries, consumers are easily inclined to adjust, but more forceful approach are required for the case of Nigeria. On the other hand, the reduction in disposable income could totally discourage consumers who could not afford the extra cost or unable to pay for available imported environmentally friendly goods, especially in the short term.

Production tax, whichmay take the form of per unit of emission and targets production activities of firms, induces producers in a country to adopt environmentally efficient techniques of production. This policy differs across Nigeria and her partners. In the EU+2, such policy controls pollution at the source based on precautionary principle, coordinated at both the regional and individual country level. Among these countries, carbon pricing gap is therefore very low. In Asia, as well as Nigeria, production tax has been less effective as the focus is neither onprecautionary or on reducing carbon pricing gap which remained high in the region.Hence, while short-run cost to adjustment by firms may be low in the EU+2, it tends to remain high in Asia and Nigeria. Productionof output by sectors, according to the H-O model, depends on endowment factors (inputs)–capital (K^s)and labour (L^s) such that:

$$Q^s = f(L^s, K^s) \ldots\ldots 1$$

Where Q denotes the output of sector s while$L$and Krepresents the quantity of labourand capital that the sectorchooses to employ respectively. The marginalproducts of factor $L$and K are positive but declining as the inputs increase.

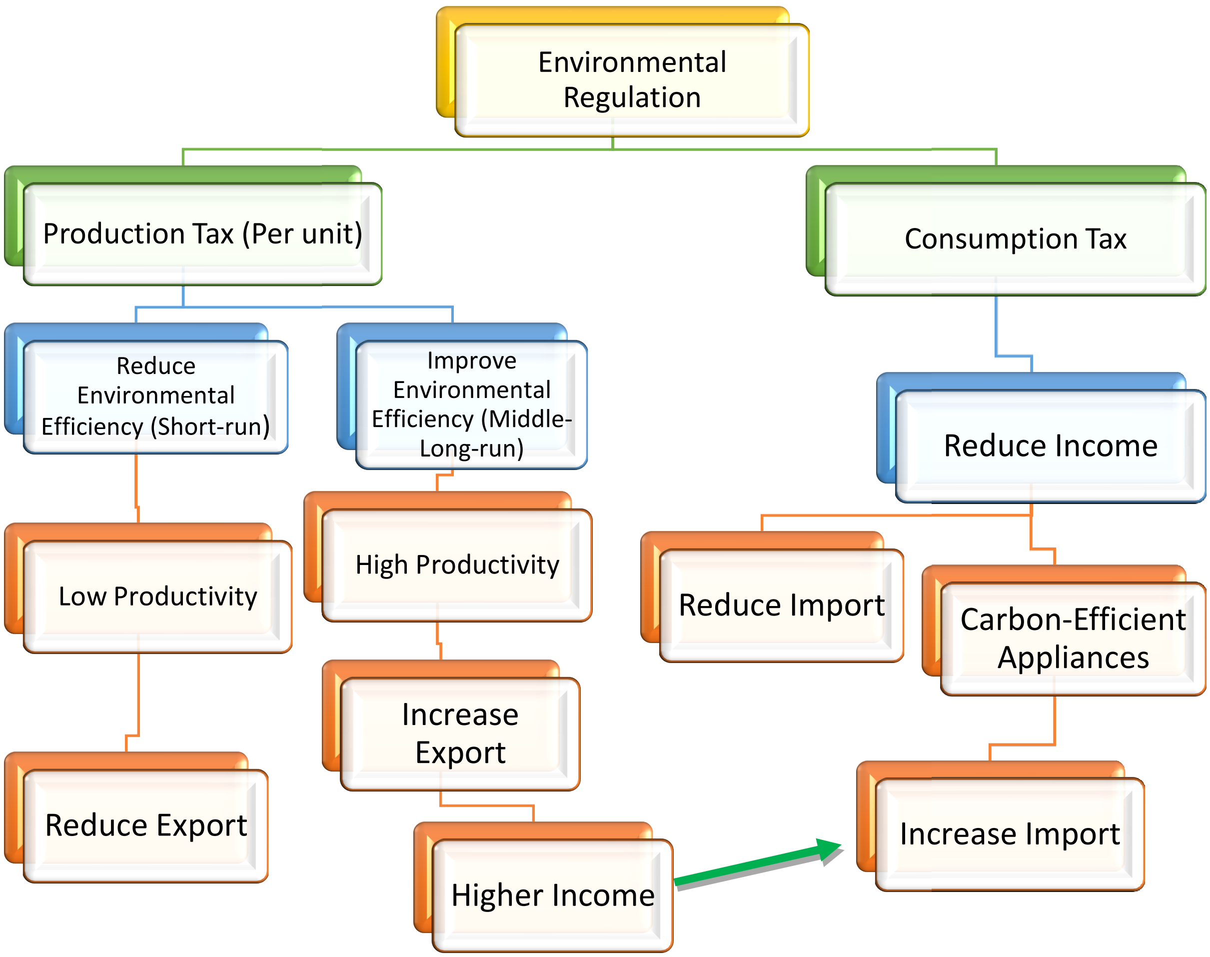

Figure 3.1. Environmental Efficiency and Trade
Source: Author, 2017

Given the assumption of constant return to scale, equation 1 can be expressed in form of Cobb Douglas function as:

$$Q = AL^aK^b, \quad A = \bar{A}; \quad \alpha + \beta = 1 \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. 2$$

The efficiency of the production technique (including environmental efficiency) of firm (measured by A) is directly affected by the regulations (environmental laws inclusive) enforced by the social planner. Thus, changes in environmental efficiency are reflected in changes in A, though the speed at which this occurs may differ between the EU+2 and Asia, as well as Nigeria due to differences in policies, implementation and adaptation. Adoption of environmentally friendly techniques involves costs that alter productivity and serve as a distortion to trade given the associated changes in cost of production. A given reduction in the per unit environmental cost as output expands or pollution falls is equivalent to improvement in environmental efficiency (Doganay et al, 2014). Such regulation can improve environmental efficiency of firms in terms of reduced costs and increased output as well as the competitiveness of domestic firms in the foreign market. It is also possible that the regulation may reduce environmental efficiency of some firms where it appears costly for them to adopt such technology. Hence, they continue to pay the tax as a license to increase pollution. In essence, environmental efficiency can either increase or reduce.

These effects may however differ between the short-run, medium-run and the long-run. In the short-run, production (environmental) tax raise production cost and reduces output as firms may cut down production to reduce the amount of tax paid or reduce emission per unit of output. However, the effect of this on pollution depends on whether or not action is taken by firms to reduce pollution by adopting low carbon technology. Thus, environmental tax may not necessarily increase environmental efficiency and competitiveness (domestic and international), given the associated higher production costs and uncertain pollution outcomes. In the medium to long-run, adoption of low carbon technology eliminates or reduces environmental tax, increases output and reduces pollution, which eventually enhances competitiveness.

In the event where environmental regulation reduces environmental efficiency, a decrease in this efficiency raises cost of production in two ways. First, increased environmental pollution generated in the production process impact costs on the environment with adverse effect on the health of people who are not directly involved in such activities (Isola and Mesagan, 2014). Such concerns may generate tension in the community affected which could result in serious implication for the production activities as well as income of the firms. Second, firms whose activities are sources of environmental degradation are major targets for environmental regulations (Ambec et al, 2011 and Rubashkina et al, 2015). These firms are usually compelled to pay huge tax and undertake corporate social responsibility (CSR) in order to make them responsible for their environmental actions. The policy environment in Nigeria and some Asian partners may present certain peculiar case. In these countries, such policies are poorly enforced and are grossly inefficient. For instance, there has been ongoing environmental degradation caused by oil spillage and gas flaring from oil production, especially in the Niger Delta region of Nigeria, which has led to the destruction of biodiversity (Faga and Uchechukwu, 2019). The responsible firms have paid little or no attention to this development, leading to agitations, pipeline vandalization and unrest in the region. The poor pollution tax system and inadequate CSR is also evident in the non-oil sector.The associatedcosts technically reduce output and competitiveness of these producers in the international markets, and reduce export, except where the demand for such product is inelastic as may be observed in the case of Nigeria's import of consumer and industrial goods. Such reduction in competitiveness and export may even become intense with high pollution intensive/embedded export product which may worsen environmental quality in the importing country.

Moreover, irrespective of the level of development, the quest for environmental efficiency pushes firms to be innovative, loweringthecostof production and increases level of compliance with associated regulations,whichinturn increases resourceefficiency andproductvalue,andenhance firms' productivity and competitiveness in the process (Gray, 2002 and Rubashkina et al, 2015). Such products also have high likelihood of meeting international environmental standards. Thus, comparative advantage is further enhanced, leading to increase in exports and decrease in imports. This leads to substitution effect as countries switch from consuming high-cost imported goods to low-cost domestically-produced goods (Doganay, et al, 2014). This has been evident for the case of the EU+2, rather than Nigeri and Asia overtime. There is also associated indirect income effect where increased efficiency reduces costs and increases output leading to high income levels which in turn contribute to increasing imports and the overall changes in imports become uncertain. If the substitution effect outweighs the income effect, then the cost advantage (or efficiency improvement) is expected to decrease imports. If otherwise, then the cost advantage is expected to increase imports. Therefore, the effect of environmental policies or efficiency on bilateral trade is modelled similar to those produced by taxes and subsidies.

Thus, with improvement in environmental efficiency, production and exports of the crude oil, which uses the most abundant resource intensively, rises. Consequently, the relationship between consumer and producer prices (*p* and *q*respectively) for crude oil (*C*) in the exporting country (Nigeria) is given as follows:

$$q = p(1-s) < p \quad \text{……………………………………………….. 3a}$$

This relationship can be rewritten as;

$$q = q_c/q_y = p_c(1-s)/p_y < p_c/p_y = p \quad \text{…………………………………3b}$$

Thus, relative world producer price (q) is higher (rises in Nigeria and lower in Partner country) relative to consumer price and world price (p^*). However, consumers, not producers, face world prices. As a result, production activities in Nigeria shifts to point Q_{N1} while those in the Partner country shifts to point Q_{P1}as shown in Figure 3.2[26].

[26]The initial H-O position is depicted in Figure B1 in the Appendix.

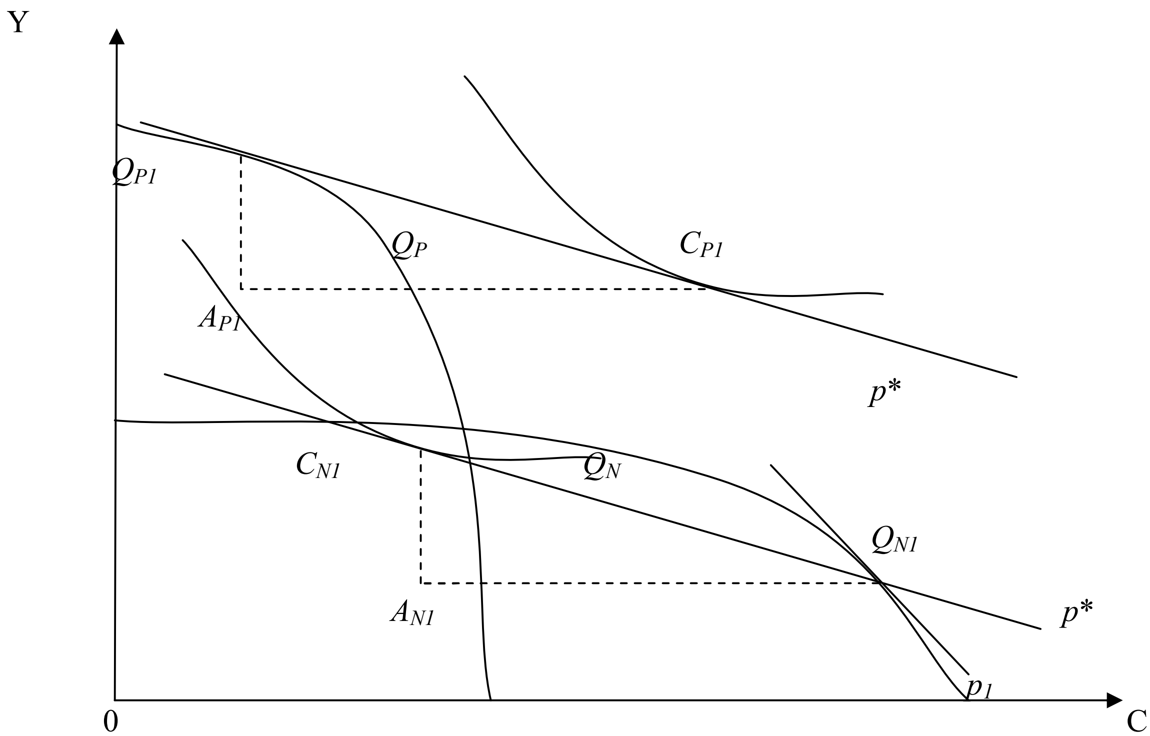

Figure 3.2. Environmental efficiency and the H-O model
Source: Author, based on Markusen et al, (1995)

Since consumers in Nigeria and the Partner country wishes to consume at point C_{N1} andC_{P1} respectively, price, p^* must fall for equilibrium to be reached. Partner country's import demand for crude oil is now given as $A_{P1}C_{P1}$ which is the same Nigeria's export supply of $A_{N1}Q_{N1}$ while Nigeria's import demand for consumer and industrial goods amounts to $A_{N1}C_{N1}$, the same amount of Partner country's export ($A_{P1}Q_{P1}$).

Similar explanation is valid for an improvement in environmental efficiency in the Partner country. Therefore, by reducing production cost, environmental efficiency makes firms more productive and increases their competitiveness in international market and generates trade. The reverse could be true where the cost of adoption of environmentally-friendly techniques outweigh the benefits with the associated higher direct cost of adjusting production process(Rubashkina et al, 2015). Hence, environmental efficiency becomes an important element in import demand and export supply functions.

Traditionally, import demand is modelled as a function of two determinants, namely real domestic income and relative prices (Hong, 1999 and Krugman and Obstfeld, 2005). Similarly, export supply is modelled as a function of real income of the trading partner and relative prices. Thus, following the foregoing discussions, an extended bilateral trade model becomes;

$$M_{ij} = f(Y_i, P, EF_i, EF_j) \quad \ldots\ldots\ldots 4$$

$$X_{ij} = f(Y_j, P, EF_i, EF_j) \quad \ldots\ldots\ldots 5$$

Where M_{ij} is the total import of country i from country $j$and X_{ij} is the total export of country i to country j.Yi and Yj are the incomes of country i and j respectively, EFiandEF_jrepresent environmental efficiency levelsin countries i and j respectively while P is the relative prices.

A number of other factors have been identified to influence bilateral trade, chief among which are trade agreement and industrialization (Borchert and Yotov, 2017).In particular, Nigeria has trade agreements with theEU+2 while she is also a member of a number of regional integrations. The wave of industrialization in the economies of partners in Asia is a critical consideration for the increased bilateral trade relation between Nigeria and countries in the region. Thus, the positive role of these factors is recognised in bilateral trade. However, the role of environmental efficiency can be examined in the face of the existing trade agreements and rising industrialization by interacting environmental efficiency with these variables. Other factors identified in the theoretical literature, influencing bilateral trade among nations include contiguity (Anderson and Van Wincoop, 2003; Feenstra, 2004 and Baier and Bergstrand, 2007) and common language(Anderson and Marcouiller, 2000; Wu, et al 2012).In bilateral trade relations, the closer countries are to each other, the larger the volume of trade expected between them due to the advantage of shorter distance and lower transaction cost (including those related to transport). While common colony implies strong cultural and social ties, common language aid effectiveness and ease of transactions between the countries involved. Thus, these variables are expected to have positive influence on both import and export of Nigeria from and to the top trading partners. The role of resource endowment is also captured following H-O model, with positive or negative theoretical expectation depending on the sector being considered. All these variablesare taken into consideration in the specified models for estimation.

3.3 Methodology

3.3.1 Model Specification

Following from the arguments in the theoretical framework provided in the previous section, environmental efficiency may be important for bilateral trade among countries. A common approach of exploring the drivers of bilateral trade flows among the trading partners is gravity model. The study therefore adapts the gravity model to analyse drivers of bilateral trade as presented in equations 4 and 5. Thus, trade (T) between country *i*and country *j* is proportional to the product of their economic sizes(GDP_i and GDP_j) and inversely related to the distance (D_{ij}) between the two countries (Krugman and Obstfeld, 2005 and Deen-Swarray, et al, 2012). This model has subsequently been employed by studies focusing on Nigeria and Africa such asAdewuyi andBankole(2012),Bankole, et al. (2012), andAdewuyi and Olubiyi (2015).

Since environmental efficiency could be an attraction or repellent for trade, much like distance, an extended gravity model of trade is adopted to present bilateral trade relationship between Nigeria and its trading partners in line with the extended H-O model[27].

$$T_{Nj} = A(GDP_N*GDP_j)/D_{Nj} \text{ ………………………………………….6}$$

*A*is agravitational constant while *GDPi* and *GDPj*represent the gross domestic products of country *i*(Nigeria) and country *j* (its trading partners in Europe and Asia) respectively.This specification is in line withDoganay et al, (2014) but introduces exchange rate and resource endowment(Collier and O'Connell, 2008) while dropping populationas economic sizes are already captured by the respective GDP.Hence,totalexports of country *i*to country *j* is modeled as a function of the exporting and importing countries' GDPs,distance (*D*), environmental efficiency (*EF*), exchange rate (ER),resource endowment (*RE*), contiguity (*C*), common language (*CL*), common colonizer (*COL*), industrialization (*IND*) and bilateral trade agreement (*BTA*), as well as their interaction with environmental efficiency which could also influence bilateral trade. These interactions are captured as *IND*EF* and *BTA*EF* respectively[28].

$$X_{tNj} = f(GDP_{Nt}, GDP_{jt}, D_{Njt}, EF_{Nt}, EF_{jt}, ER_{Nt}, ER_{jt}, RE_{Nt}, RE_{jt}CL_{Nj}, COL_{Nj}, BTA_{tNj}, IND_{jt}, IND_{jt}*EF_{Nt}, IND_{jt}*EF_{jt}, BTA_{tNj}*EF_{Nt}, BTA_{tNj}*EF_{jt},) \text{ ....7}$$

$$M_{tNj} = f(GDP_{Njt}, GDP_{jt}, TC_{Njt}EF_{Nt}, EF_{jt}, ER_{Nt}, ER_{jt}, RE_{Nt}, RE_{jt}, CL_{Nj}, COL_{Nj}, BTA_{tNj}, IND_{jt}, IND_{jt}*EF_{Nt}, IND_{jt}*EF_{jt}, BTA_{tNj}*EF_{Nt}, BTA_{tNj}*EF_{jt},) \text{.. ....8}$$

The econometric specification of the models is given as follows;

$$InX_{zNjt} = \alpha + \theta_1 InGDP_{Nt} + \theta_2 InGDP_{jt} + \theta_3 D_{NJt} + \theta_4 InEF_{Nt} + \theta_5 InEF_{jt} + \theta_6 InER_{Nt} + \theta_7 InER_{jt} + \theta_8 InRE_{Nt} + \theta_9 InRE_{jt} + \theta_{10} CL_{Njt} + \theta_{11} COL_{Njt} + \theta_{12} BTA_{tNj} + \theta_{13} lnIND_{jt} + \theta_{14} lnIND_{jt} * lnEF_{Nt} + \theta_{15} lnIND_{jt} * lnEF_{jt} + \theta_{16} lnBTA_{tNj} * lnEF_{Nt} + \theta_{17} lnBTA_{tNj} * lnEF_{jt} + \pi_t \text{ ....9}$$

[27]Studies that have contributed immensely to the theoretical development of the gravity model of trade include Armington (1969), Anderson (1979), Bregstrand, 1985, and Anderson and van Wincoop (2003)

[28]Environmental efficiencies in both partners were interacted with industrialization in the partner country to yield two indicators – $INDEF_N$ and $INDEF_J$. Similarly, two indicators were obtained for the interaction of BTA with environmental efficiencies of both countries - $BTAEF_N$ and $BTAEF_J$.

$$InM_{zNjt} = \alpha + \theta_1 InGDP_{Nt} + \theta_2 InGDP_{jt} + \theta_2 D_{NJt} + \theta_4 InEF_{Nt} + \theta_5 InEF_{jt} + \theta_6 InER_{Nt} + \theta_7 InER_{jt} + \theta_8 InRE_{Nt} + \theta_9 InRE_{jt} + \theta_{10} CL_{Njt} + \theta_{11} COL_{Njt} + \theta_{12} BTA_{tNj} + \theta_{13} lnIND_{jt} + \theta_{14} lnIND_{jt} * lnEF_{Nt} + \theta_{15} lnIND_{jt} * lnEF_{jt} + \theta_{16} lnBTA_{tNj} * lnEF_{Nt} + \theta_{17} lnBTA_{tNj} * lnEF_{jt} + \pi_t \ldots\ldots 10$$

Where z equals total trade and sectoral trade (mineral and non-mineral), and non-minerals trade involves agricultural and manufacturing goods). The dependent variable InX_{zNjt} in equation 10 is exports of commodity *z* from country *N* (Nigeria) to country *j* (each of its major trading partners) at year *t*. The dependent variable InM_{zNjt}in equation 11 is imports of country *N* (Nigeria) of commodity *z* from country *j* (each of its major trading partners).

3.3.2 Estimation Technique and Method of Analysis

Estimating the role of environmental efficiency in bilateral trade begins with a first stage analysis where the efficiency scores are obtained for each of the countries of interest. This stageis based upon a production approach which differentiates betweenthe disposability characteristics of environmentally desirable and undesirable outputs in line with Doganay et al (2014). This follows the fact that changes in regulation, international market demand and pressures as well as pure technological advancements can alter pollutants' disposability characteristics. This yields an alternative and moreprecise measure of environmental costs as it accounts for the change in the overall productionprocess. Furthermore, the resulting environmental efficiency index reflects the amount of desirable output sacrificed in order to reduce the pollutant by one unit. This measure is comparable across producers over time.

This study therefore follows the proposition that environmental performance in form of efficiency can be measured by constructing an index using bad and good efficienciesto obtain net efficiency ratio (Färe et al., 2003; Zaim et al., 2001; Zaim, 2004; Halkos and Tzeremes, 2009). This is done using non-parametric technique(data envelopment analysis-DEA) where good output (GDP) and inputs (labour, capital and energy consumption) make up the formulation for good efficiency, while bad output (carbon emission) and the same inputs complete the formulation for bad efficiency[29].The scores for both good and bad efficiency range from 0 to 1. Then, environmental efficiency ratio is computed by finding the ratio of good efficiency to bad efficiency, where higher ratio indicates higher (or improvement in) environmental efficiency of a country. Also, a score (ratio) higher than one indicates that the good efficiency outweighs the bad efficiency.An improvement in theenvironmental efficiency index of producing a unit of output indicates that the cost to moreenvironmentallyconscious producers declines and the cleanup costs are smaller, a situationthat is likely to improve the producers' comparative advantage. The choice of the Slack-based measure ofDEA over the parametric technique is based on a number of its overriding strengths. First, it requires no mathematical functional form in its formulation which makes it easy to compute. Second,the technique is capable of accommodating multiple inputs and outputs. Finally, it allows the identification and analysis ofthe source of inefficiency for every evaluated unit (Coelli et al., 2005).

In line with Asmild et al. (2004) and Halkos and Tzeremes (2009), the study considers *N* number of Decision Making Units (DMUs) (n=1,…, N) and *T* periods (t=1,…,T) using m inputs and s outputs creating a sample of $N \times T$ observations in the process. An observation n in period t, (DMU_t^n) has an m dimensional input vector $x_t^n = (x_{1t}^n, x_{2t}^n, \dots, x_{mt}^n)$ and an s dimensional output vector $y_t^n = (y_{1t}^n, y_{2t}^n, \dots, y_{st}^n)$.

The constant returns to scale DEA cost minimization problem for $DMU_{qt}$is analysed by solving the following linear programming problem;

$$\text{Minimise } \theta_q \quad \dots\dots 11$$

Subject to:

$$\sum_{j=1}^{n} \lambda j X ij \leq \theta X_{iq} i = 1, \dots, m \quad \dots\dots 12$$

$$\sum_{j=1}^{n} \lambda j Y rj \geq Y_{rq} r = 1, \dots, s \quad \dots\dots 13$$

$$\lambda j \geq 0 \qquad j = 1, \dots, n \quad \dots\dots 14$$

$\theta = 1$ indicates a technically efficient DMU and λj is a N X 1 vector that shows the proportion of referencing *DMUj*when measuring the efficiency of *DMUq*. The problem is

[29]Carbon emission is selected for three reasons. First, it is the largest component of greenhouse emission in Nigeria rising by over 150% between 1990 and 2012. Second, it is the dominant measure of environmental pollution in the environment-trade literature (Cristea et al, 2013; Doganay et al, 2014 and Honma, 2015). Third, data on other sources of environmental pollution in Nigeria is limited.

to seek the efficiency rating, minimize cost,θ_{q},,subject to two constraints. First, the weighted sum of the inputs of the otherservice units is less than or equal to the inputs of the service unit being evaluated and second, the weighted sum of the outputs of the otherservice units is greater than or equal to the service unit beingevaluated. The linear programmingmodel above is solved n number of times, once for each DMU, generating avalue of θ for each DMU. The CRS assumption is appropriate in cases where all DMUsoperate at an optimal scale. However, constraints on DMUs (at least some DMUs) may exist which do not allow them to operate at the optimal scale. Using CRS for such DMUs will yield Technical Efficiency (TE) scores, which are affected by Scale Efficiencies (SE). Therefore, the study also employs Varying Returns to Scale (VRS) model by adding the restriction $\sum_{1}^{n} \lambda n = 1$(Banker et al, 1984), as the countries of interest have different sizes which can influence their ability to be efficient in producing output. Thus, VRS is less restrictive and allows the best practice level of outputs to inputs to vary with the size of the countries in the sample (Halkos and Tzeremes, 2009).

In the second stage analysis, this study adopts the random effect generalized least square (GLS) technique for the aggregate analysis as there are no issues of missing valuesin addition to the small sample size (Clark and Linzer, 2015). This method is also robust and more efficient than the ordinary least square under heteroscedasticity while highly correlated variables are used in their first-difference. The study further utilized the Arellano-Bond Dynamic Generalized Method of Moments (GMM) estimator due to its robustness where there is possibility of endogeneity. The Sargan test of overidentifying restrictions, with the null hypothesis that overidentifying restrictions are valid, is employed to examine the validity of the instruments.However, for the disaggregate analysis, the count-data models, particularly the negative binomial pseudo maximum likelihood model (NBPMLM) is employed. This method is capable of handling some methodological shortcomings in the estimation of the gravity model such as autocorrelation, simultaneity bias and heteroskedasticity (Santos and Tenreyro, 2006) as well as excessive presence of zero values in the bilateral trade data (Frankel, 1997; Linders and Groot, 2007; Turkson, 2011; Burger et al (2009).Unlike the Poisson maximum likelihood regression, NBPMLM allows dispersion to exist between the mean and variance of the bilateral trade distribution. Thus, it is a mixture of thePoisson distribution and the Gamma distribution, or generalizedfactorial function, and it is a function of both μ and α. Its mean is still μ, but itsconditional variance is μ(1 + αμ). As asα→ 0, thedistribution of bilateral trade becomes the Poisson distribution.

The likelihood ratio test of α = 0 strongly rejects the null hypothesisthat the errors do not exhibit overdispersion. Thus, the Poissonregression model is rejected in favor of its generalized version, the negative binomial regression model. The coefficients are similar between the twomodels, and the negative binomial estimates are comparable to those fromPoissonwith robust standard errors.Since the summary statisticsshow that the means and variance are not thesame, the negative binomial regression is adopted for this study. Besides, the negative binomial regression model can be viewed as an extension of the Poissonregression, it addresses the over-dispersion issue better and has parameterizationsthat differ from the Poisson model(Piperopoulos*et al*, 2017).

3.3.3 Data and Variable Description

Empirical analysis in this study spans the period 1996-2015 due to data availability constraint. Data used in this research are derived from various sources shown in Table 3.1. Bilateral trade flows are obtained from World Integrated Trade Solution (WITS) database developed by the World Bank with values expressed in million USD. This thesis follows the literature regarding the trade flows by defining commodity structure as the categories 0-9 of SITC Revision 2.The bilateral exports and imports follow the one-digit division classification of trade. The database separates both the export and import flows into 10 categories such as "0-Food and live animals"; "1-Beverages and tobacco"; "2- Crude materials, inedible, except fuel"; "3- Mineral fuels, lubricants and relate"; "4- Animal and vegetable oils, fats"; "5- Chemicals and related products"; "6-Manufactured goods classified chief"; "7- Machinery and transport equipment"; "8- Miscellaneous manufactured articles"; "9- Commodities and transactions not el." The study employs mirror data to reduce the number of missing values, and all selected countries are listed in Tables A4a and A4b in the Appendix.

Table 3.1. Variable Description and Sources

Variable	Description	Measurement	Data sources	A priori expectation
Xz_{NJ}	Total Export of Nigeria to her trading partner	US Dollars in real terms (SITC revision 1 CODE 0-9)	Computed using data from WITS (COMTRADE) and commodity price published by the World Bank	
Mz_{NJ}	Total Import of Nigeria from her trading partner	US Dollars in real terms (SITC revision 1 CODE 0-9)	Computed using data from WITS (COMTRADE) and commodity price published by the World Bank	
MX_{NJ}	Mineral Export of Nigeria to her trading partner	US Dollars in real terms (SITC revision 1 CODE 3)	Computed using data from WITS (COMTRADE) and commodity price published by the World Bank	
MM_{NJ}	Mineral Import of Nigeria from her trading partner	US Dollars in real terms (SITC revision 1 CODE 3)	Computed using data from WITS (COMTRADE) and commodity price published by the World Bank	
NX_{NJ}	Non-Mineral Export of Nigeria to her trading partner	US Dollars in real terms (SITC revision 1 CODE 0-9 except 3)	Computed using data from WITS (COMTRADE) and commodity price published by the World Bank	
NM_{NJ}	Non-Mineral Import of Nigeria from her trading partner	US Dollars in real terms (SITC revision 1 CODE 0-9 except 3)	Computed using data from WITS (COMTRADE) and commodity price published by the World Bank	
AX_{NJ}	Agricultural Export of Nigeria to her trading partner	US Dollars in real terms (SITC revision 1 CODE 0 and 4)	Computed using data from WITS (COMTRADE) and commodity price published by the World Bank	
AM_{NJ}	Agricultural Import of Nigeria from her trading partner	US Dollars in real terms (SITC revision 1 CODE 0 and 4)	Computed using data from WITS (COMTRADE) and commodity price published by the World Bank	
MAX_{NJ}	Manufacturing Export of Nigeria to her trading partner	US Dollars in real terms (SITC revision 1 CODE 1, 6 and 8)	Computed using data from WITS (COMTRADE) and commodity price published by the World Bank	
MI_{NJ}	Manufacturing Import of Nigeria from her trading partner	US Dollars in real terms (SITC revision 1 CODE 1, 6 and 8)	Computed using data from WITS (COMTRADE) and commodity price published by the World Bank	
GDP_N	Gross domestic product per capita of Nigeria	Constant 2005 (billion US dollars)	World Bank, World Development Indicators	+
GDP_j	Gross domestic product per capita of the trading partner	Constant 2005 (billion US dollars)	World Bank, World Development Indicators	+
D_{NJ}	Distance	Distance between the capital cities of Nigeria and her partners	CEPII gravity dataset	-
EF_N	Environmental efficiency score in Nigeria	Good efficiency score divided by bad efficiency score	Computed	+/-
EF_j	Environmental efficiency score in the partner economy	Good efficiency score divided by bad efficiency score	Computed	+/-
ER_i	Real exchange rate in Nigeria	Real effective exchange rate index (2010 = 100)	World Bank, Global Economic Monitor	+
ER_j	Real exchange rate in partner *i*	Real effective exchange rate index (2010 = 100)	World Bank, Global Economic Monitor	-/+
RE_N	Resource endowment	Capital-Labour Ratio in Nigeria	World Bank, World Development Indicators	+/-
RE_j	Resource endowment	Capital-Labour Ratio in the economy of the partner	World Bank, World Development Indicators	+/-
CL_{NJ}	Common language	Dummy variable for common language	CEPII gravity dataset	+
COL_{NJ}	Common colony	Dummy variable for common colonial ties	CEPII gravity dataset	+
BTA_{NJ}	Bilateral Trade Agreement	Dummy variable for Bilateral trade Agreement between the partner countries i& j	CEPII gravity dataset	+
IND_N	Industrialization in Nigeria	Industrial value added (constant 2005 US$)	World Bank, World Development Indicators	+
IND_J	Industrialization in the partner country	Industrial value added (constant 2005 US$)	World Bank, World Development Indicators	+
$IND*EF_N$	Industrialization (partner)-Efficiency(Nigeria) Interaction	Product of industrialization and efficiency values	Computed	+
$IND*EF_j$	Industrialization (partner)-Efficiency(Partner) Interaction	Product of industrialization and efficiency values	Computed	+
$BTA*EF_N$	BTA-Efficiency (Nigeria) Interaction	Product of BTA and efficiency values	Computed	+
$BTA*EF_j$	BTA – Efficiency (Partner)	Product of BTA and efficiency values	Computed	+

	Interaction			

Source: Author's compilation

CHAPTER FOUR

ANALYSIS AND DISCUSSION OF RESULTS

4.1 Introduction

This chapter contains analysis, interpretation and discussion of results on the effect of environmental efficiency on bilateral trade between Nigeria and her top trading partners in the EU+2 and Asia. The chapter starts with a discussion of the computed environmental efficiency scores for Nigeria and her trading partners in Asia and EU+2. It thereafter discusses the preliminary analysis before presenting results on the effect of environmental efficiency on bilateral trade between Nigeria and Asia, as well as the EU+2. The chapter is concluded with a discussion of findings of the study.

4.2 Preliminary Analysis

4.2.1 Descriptive Statistics

Tables4.1a and 4.1b report summary statistics, showing the mean, maximum, minimum and standard deviation of the variables used for regression analysis. Mean total export of Nigeria to the EU+2 top partners, as well as import from the same partners, is higher than those observed for the Asian partners, although the maximum values are in favour of the Asian partners. The standard deviation statistics show that, while variability is higher for export to the EU+2 partners than to Asian partners, Nigeria's import from the latter is more volatile than those from the former. Similarly, on the average, Nigeria's bilateral trade (import and export) in mineral product with the selected top partners in the EU+2 is higher than the country's average mineral trade with Asia. Mean volume of manufacturing and agricultural exports of Nigeria to trading partners in the EU+2 is larger than such exports to Asian partners. However, average volume of manufacturing import from Asian partners is larger than such import from the EU+2. Some level variability of is also observed in these trade volumes.

Furthermore, environmental efficiency score ranges from 0.65 to 2.04 among top trading partners in Asia and from 0.55 to 3.43 among partners in the EU+2, with average score of 1.13 and 1.14 respectively. Also, as suggested by the standard deviation statistics, these scores are more volatile among Asian partners than the EU+2 partners. This reveals higher dispersion in environmental efficiency among partners in Asia than those in the EU+2. This may be expected as the EU+2 and Asian partners are not compared with one another in the same environmental efficiency analysis.

Environmental efficiency score is higher whenNigeria is analyzed relative to her Asian partners with a mean of 1.83 (ranging from 0.72 to 3.20) than when the country is analysed relative to the EU+2 partners where the mean is 1.18 (ranging from 0.71 to 1.54). The standard deviation of environmental efficiency in Nigeria and the partner country is higher in relation to the Asian partners than the EU+2 partners. Again, variability and dispersion in environmental efficiency in Nigeria appears to be higher than those observed for the EU+2 partners and lower than those of Asian partners.

Table 4.1. Summary Statistics for the Nigeria-Asia Models

Variables	Mean	Maximum	Minimum	Std. Dev.
	1347937	15663352	470.79	2881865
M_{NJ}	1126580	15393425	1187.60	2407519
MX_{NJ}	1298665	15500788	0	2850463
MM_{NJ}	10884.06	332462	0	34168.47
NX_{NJ}	49272.16	511591.10	136.95	73801.55
NM_{NJ}	1115696	15300282	1187.60	2402130
MAX_{NJ}	12637.31	90602.04	0	18845.39
MAM_{NJ}	451189.8	8502715	721.32	1254229
AX_{NJ}	3688.40	67287.38	0	9807.15
AM_{NJ}	42829.48	548872.50	0	89638.61
EF_J	1.13	3.43	0.55	36.86
EF_N	1.83	3.20	0.72	78.21
RE_J	10284.43	24254.81	383.58	8232.31
RE_N	440.89	440.89	440.89	0
COL_{NJ}	0.43	1	0	0.50
DIS_{NJ}	11181.33	13024.73	7782.85	1531.35
GDP_J	19741.39	51855.08	663.62	17292.85
GDP_N	1619.43	2548.427	1247.838	478.19
$INDEF_J$	65.10**	435.00**	1.53**	83.50**
IND_N	56.50*	56.50*	56.50*	0
IND_J	642.00*	4.18**	14*50	839.00*
LAN_{NJ}	0.57	1	0	0.496649
$INDEF_N$	131.00**	1340.00**	1.26**	223.00**
ER_N	64.98	64.98	64.98	0
ER_J	101.62	155.15	64.33	15.71
BTA_{NJ}	-	-	-	-
$BTAEF_J$	-	-	-	-
$BTAEF_N$	-	-	-	-

Source: Author Computation, data from various sources (Table 4.1):

Note Values with * are in billion while those with *** are in trillion.

Table 4.1. Summary Statistics for the Nigeria-EU+2 Models

Variables	Mean	Maximum	Minimum	Std. Dev.
	1462115	9074047	64	1886152
M_{NJ}	771719	5300431	3213	925356
MX_{NJ}	1371617	8949094	0	1844109
MM_{NJ}	218310	4193210	0	603736
NX_{NJ}	84903	507051	0	100708
NM_{NJ}	564901	2153281	0	552008
MAX_{NJ}	19080	201240	0	38633
MAM_{NJ}	120889	585185	0	123899
AX_{NJ}	44149	420028	0	75582
AM_{NJ}	60375	525083	0	93898
EF_{J}	1.14	2.04	0.65	0.32
EF_{N}	1.18	1.54	0.71	0.27
RE_{J}	19210.32	40189.28	6277.67	7340.78
RE_{N}	629.2413	1343.05	359.901	306.83
COL_{NJ}	0.1	1	0	0.30
DIS_{NJ}	4636.17	5852.89	3684.67	724.95
GDP_{J}	45612.31	91593.67	18643.65	18458.43
GDP_{N}	1619.43	2548.43	1247.83	478.19
$INDEF_{J}$	364.00*	1.12**	33.30*	281.00*
IND_{N}	71.70*	11.10*	54.90*	18.7*
IND_{J}	323.00*	1.02**	42.9*	247.00*
LAN_{NJ}	0.2	1	0	0.40
$INDEF_{N}$	38.10**	157.00**	3.79**	31.00**
ER_{N}	79.09	119.96	64.98	18.06
ER_{J}	100.89	130.87	84.41	8.77
BTA_{NJ}	0.70	1	0	0.46
$BTAEF_{J}$	81.21	205.17	0	60.56
$BTAEF_{N}$	83.86	154.64	0	58.74

Source: Author Computation, data from various sources (Table 4.1):

Note Values with * are in billion while those with *** are in trillion.

4.2.2 Correlation Analysis

Results of correlation analysis of the variables used in regression analysis are reported in Table 4.2 (a and b) for Nigeria-EU+2 bilateral trade model and Table 4.3 (a and b) for Nigeria – Asia bilateral trade model. Due to the nature of economic variables which are correlated at various degrees, a correlation coefficient greater that 0.90 ($r > 0.90$) is assumed to be very high (Asuero et al, 2006) which may require further considerations. As observed from Tables 4.2a and 4.2b, weak to moderate relationship exists among most of the Nigeria-EU+2variables, with few exceptions.For instance, in the Nigeria-EU+2 bilateral trade models, very high correlation coefficients are found between resource endowment in the EU+2 partner and GDP per capital in Nigeria, resource endowment and each of GDP and exchange rate in Nigeria, GDP (Nigeria) and each of industrialization and exchange rate in Nigeria, and industrialization (Nigeria) and exchange rate (Nigeria).Also, agricultural export and non-mineral export, total export and mineral export, and manufacturing import and non-mineral import are also found to exhibit very high correlations. To overcome the possible multicollinearity problem, all affected variables are first-differenced in line with existing studies (Liu et al, 2009; Yusuf et al, 2020). Again, highly correlated dependent variables are in different models.Similar observation is also made in Tables 4.3a and 4.3b for Nigeria-Asia models and are similarly addressed.

Table 4.2a. Correlation Analysis of the Variables used in the Nigeria-EU+2 Models

	AX_{NJ}	AM_{NJ}	BTA_{NJ}	RE_J	COL_{NJ}	DIS_{NJ}	EF_J	X_{NJ}	GDP_J	M_{NJ}	IND_J	LAN_{NJ}	MAX_{NJ}
AX_{NJ}	1.00												
AM_{NJ}	0.48	1.00											
BTA_{NJ}	0.29	-0.19	1.00										
RE_J	-0.44	0.27	-0.68	1.00									
COL_{NJ}	0.21	0.23	0.22	-0.30	1.00								
DIS_{NJ}	-0.40	0.23	-0.37	0.52	0.17	1.00							
EF_J	-0.28	0.09	-0.03	0.44	-0.13	0.34	1.00						
X_{NJ}	0.70	0.17	0.42	-0.47	0.05	-0.64	-0.07	1.00					
GDP_J	-0.48	0.30	-0.75	0.92	-0.10	0.69	0.45	-0.56	1.00				
M_{NJ}	0.62	0.72	0.15	0.03	0.32	0.09	0.23	0.48	0.06	1.00			
IND_J	0.52	0.54	0.35	0.03	0.26	-0.05	0.04	0.31	-0.02	0.70	1.00		
LAN_{NJ}	0.44	0.45	-0.22	-0.18	0.67	0.24	-0.24	0.12	0.00	0.46	0.08	1.00	
MAX_{NJ}	0.68	0.28	0.49	-0.47	0.23	-0.62	-0.42	0.61	-0.57	0.40	0.48	0.11	1.00
MAM_{NJ}	0.66	0.68	0.26	-0.03	0.33	-0.03	0.12	0.46	-0.04	0.81	0.67	0.30	0.61
MM_{NJ}	0.73	0.53	0.30	-0.26	0.20	-0.20	-0.09	0.60	-0.32	0.75	0.41	0.38	0.59
EF_N	0.01	-0.02	0.00	-0.07	0.00	0.00	0.10	0.19	-0.01	0.08	-0.03	0.00	0.05
RE_N	0.12	0.18	-0.05	-0.04	-0.21	-0.02	0.06	0.22	0.02	0.31	0.04	-0.05	0.07
NX_{NJ}	0.92	0.53	0.32	-0.37	0.21	-0.38	-0.29	0.67	-0.44	0.66	0.55	0.38	0.80
GDP_N	0.15	0.20	-0.06	-0.03	-0.25	-0.03	0.03	0.19	0.02	0.31	0.06	-0.06	0.08
NM_{NJ}	0.59	0.74	0.11	0.13	0.29	0.15	0.21	0.32	0.13	0.82	0.62	0.34	0.47
IND_N	0.16	0.21	-0.06	-0.04	-0.28	-0.03	0.00	0.16	0.01	0.29	0.07	-0.07	0.07
ER_N	0.15	0.21	-0.06	-0.03	-0.27	-0.03	0.01	0.18	0.01	0.30	0.06	-0.07	0.07
ER_j	0.05	0.07	0.25	-0.20	0.65	0.31	0.11	-0.07	-0.04	0.28	0.17	0.40	0.04
MX_{NJ}	0.68	0.20	0.38	-0.40	0.06	-0.55	-0.03	0.92	-0.50	0.44	0.26	0.11	0.62

Source: Author Computation, data from various sources (Table 4.1)

Table 4.2b.CorrelationAnalysisof the Variables used in theNigeria-EU+2Models

	MAM_{NJ}	MM_{NJ}	EF_N	RE_N	NX_{NJ}	GDP_N	NM_{NJ}	IND_N	ER_N	ER_J	MX_{NJ}
MAM_{NJ}	1.00										
MM_{NJ}	0.64	1.00									
EF_N	-0.01	0.08	1.00								
RE_N	0.05	0.30	0.32	1.00							
NX_{NJ}	0.76	0.77	0.02	0.16	1.00						
GDP_N	0.06	0.31	0.25	0.92	0.18	1.00					
NM_{NJ}	0.96	0.63	-0.02	0.06	0.70	0.08	1.00				
IND_N	0.04	0.29	0.11	0.87	0.18	0.97	0.06	1.00			
RER_N	0.04	0.30	0.18	0.90	0.18	0.97	0.06	0.97	1.00		
ER_J	0.31	0.06	0.01	-0.11	0.06	-0.12	0.28	-0.16	-0.17	1.00	
MX_{NJ}	0.58	0.57	0.11	0.07	0.69	0.05	0.46	0.03	0.04	-0.03	1.00

Source: Author Computation, data from various sources (Table 4.1)

Table 4.3a. Correlation Analysis of the Variables used in the Nigeria-Asia Models

	AX_{NJ}	AM_{NJ}	RE_J	COL_{NJ}	DIS_{NJ}	EF_J	X_{NJ}	GDP_J	M_{NJ}	IND_J	LAN_{NJ}	MAX_{NJ}	MAM_{NJ}	MX_{NJ}
AX_{NJ}	1.00													
AM_{NJ}	0.27	1.00												
RE_J	-0.29	-0.60	1.00											
COL_{NJ}	0.34	-0.10	0.03	1.00										
DIS_{NJ}	-0.54	-0.48	0.67	-0.61	1.00									
EF_J	0.21	0.24	0.07	0.41	-0.22	1.00								
X_{NJ}	0.33	0.41	-0.36	-0.41	-0.19	-0.18	1.00							
GDP_J	-0.28	-0.62	0.99	0.05	0.68	0.11	-0.40	1.00						
M_{NJ}	0.16	0.66	-0.29	-0.46	-0.16	-0.04	0.55	-0.34	1.00					
IND_J	0.18	0.41	-0.29	-0.72	0.09	-0.28	0.67	-0.32	0.81	1.00				
LAN_{NJ}	0.02	-0.19	0.20	0.75	-0.43	0.14	-0.32	0.19	-0.35	-0.69	1.00			
MAX_{NJ}	0.39	0.12	0.09	0.11	-0.13	-0.03	0.40	0.08	0.12	0.16	0.11	1.00		
MAM_{NJ}	0.19	0.66	-0.39	-0.51	-0.17	-0.13	0.61	-0.44	0.97	0.86	-0.44	0.16	1.00	
MX_{NJ}	0.08	0.38	-0.30	-0.58	-0.05	-0.30	0.69	-0.35	0.67	0.75	-0.42	0.10	0.70	1.00
MM_{NJ}	-0.22	0.54	-0.06	-0.36	0.16	0.18	0.05	-0.09	0.50	0.25	-0.26	-0.07	0.45	0.22
RE_N	0.26	0.33	0.16	0.00	0.00	0.31	0.37	0.15	0.22	0.15	0.00	0.62	0.18	0.15
EF_N	0.16	0.26	0.14	0.00	0.00	0.18	0.31	0.11	0.13	0.12	0.00	0.47	0.08	0.14
NX_{NJ}	0.57	0.28	-0.18	0.04	-0.28	0.05	0.54	-0.17	0.27	0.41	-0.11	0.76	0.31	0.24
GDP_N	0.30	0.36	0.16	0.00	0.00	0.35	0.38	0.16	0.24	0.16	0.00	0.69	0.20	0.10
NM_{NJ}	0.16	0.66	-0.29	-0.47	-0.16	-0.05	0.56	-0.35	1.00	0.82	-0.35	0.12	0.97	0.67
ER_N	0.29	0.37	0.16	0.00	0.00	0.34	0.36	0.16	0.25	0.16	0.00	0.67	0.22	0.11
IND_N	0.31	0.35	0.15	0.00	0.00	0.34	0.35	0.16	0.25	0.16	0.00	0.67	0.22	0.09
ER_J	-0.18	-0.44	0.41	0.04	0.34	-0.15	-0.31	0.38	-0.33	-0.30	0.17	-0.03	-0.32	-0.29

Source: Author Computation, data from various sources (Table 4.1)

Table 4.3b. Correlation Analysis of the Variables used in the Nigeria-Asia Models

	MM_{NJ}	RE_N	EF_N	NX_{NJ}	GDP_N	NM_{NJ}	ER_N	IND_N	ER_J
MM_{NJ}	1.00								
RE_N	0.31	1.00							
EF_N	0.18	0.83	1.00						
NX_{NJ}	-0.13	0.55	0.46	1.00					
GDP_N	0.31	0.90	0.72	0.57	1.00				
NM_{NJ}	0.50	0.21	0.13	0.27	0.24	1.00			
ER_N	0.32	0.87	0.66	0.56	0.96	0.25	1.00		
IND_N	0.32	0.83	0.55	0.54	0.95	0.24	0.94	1.00	
ER_J	-0.05	-0.08	-0.04	-0.20	-0.12	-0.33	-0.11	-0.11	1.00

Source: Author Computation, data from various sources (Table 4.1)

4.3 Computed Environmental Efficiency Scores

Environmental efficiency in the economies of the trading partners is first computed with countries serving as decision making units. This allows an analysis of environmental efficiency performance of Nigeria relative to other trading partners. Environmental efficiency will be less than 1 where bad efficiency scores (obtained when carbon emission is the output indicator in the DEA analysis) outweigh good efficiency scores (obtained when GDP is the output indicator), and greater than 1 when the latter is greater[30].

Environmental efficiency scores of Nigeria's top trading partners in the EU+2are more stable than that of Nigeria over the period 1996-2015 when the countries are compared with the frontier (Table 4.4a). All the selected EU+2 partners improved their efficiency status or scores towards the frontier over the same period with France, Sweden and Switzerland maintaining their frontier (best performing) status throughout the period. In Spain, however, bad efficiency appeared to override good efficiency for all the years except in 2013, which makes the country the most inefficient among Nigeria' EU+2 top trading partners. Though the country has made huge progress in promoting environmental quality and ranked among the top 20 on the EPI scale, it still trails most of the selected Nigeria's partners. This may explain the poor environmental efficiency performance which are computed in relative terms. While most of the EU+2 partners performed better than Nigeria in the early 2000s, only France, Sweden and Switzerland recorded higher environmental efficiency than the country during 2008-2015.This corroborates the submission of Halkos and Tzeremes (2013a) and Halkos and Tzeremes (2013b) who reported that most of the UK regions are environmentally inefficient. The results also supportKounetas (2015) who found that environmental efficiency of the EU+2 members improved over the period 2002-2008. This may reflect the low level of industrial activities in Nigeria compared to her European partners.

Environmental efficiency scores of Nigeria's top trading partners in Asia appears more unstable during 1996-2006 than the recent years when the countries are compared with the

[30] Environmental efficiency scores are reported in Figure B2 (the Nigeria-EU) and Figure B3 (Nigeria-Asia) in the Appendix. Note that good (and bad) efficiency scores range from 0 (completely inefficient) to 1 (perfectly efficient-frontier).

frontier country (Table 4.4b). Generally, environmental efficiency improved over the period 1996-2015 among the selected Asian partners. For instance, only India, Japan and Indonesia recorded environmental efficiency scores of 1.0 or above prior to 2006, suggesting that good efficiency dominates bad efficiency in these countries. However, between 2007 and 2015, all the Asian partners scored 1.0 and above. It is also observed that Singapore is the most environmentally efficient partner in Asia reaching a peak of about 3.43 in 2007 while Korea Republic and China are the least efficient. This is consistent with the findings in the literature such as Li et al (2013b), Chen et al (2014), Chen and Jia (2016), Song et al (2016) and Xie et al (2015). When compared with most of the selected Asian partners, Nigeria enjoys higher environmental efficiency score for almost all the years with wide gap after 2008, which may be traced to the increasing wave of industrialization in these partners.

Table 4.4a: Environmental Efficiency in Nigeria in relation to the EU+2

	year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
France	BD	0.63	0.59	0.63	0.61	0.59	0.62	0.61	0.60	0.60	0.60	0.58	0.57	0.56	0.54	0.53	0.51	0.51	0.51	0.55	0.52
	GD	0.89	0.91	0.92	0.92	0.93	0.95	0.95	0.94	0.95	0.95	0.97	0.99	0.98	0.95	0.96	0.98	0.98	0.98	0.99	1.00
	EFF	1.41	1.54	1.46	1.51	1.57	1.53	1.57	1.56	1.58	1.59	1.67	1.74	1.75	1.76	1.81	1.91	1.90	1.91	1.81	1.91
Germany	BD	1.00	0.98	0.98	0.96	0.96	0.96	0.96	0.95	0.94	0.92	0.92	0.93	0.92	0.90	0.90	0.92	0.92	0.93	0.96	0.92
	GD	0.89	0.90	0.89	0.88	0.90	0.93	0.96	0.96	0.98	0.98	0.97	0.97	0.97	0.98	0.99	0.98	0.99	1.00	1.00	1.00
	EFF	0.89	0.92	0.91	0.92	0.93	0.96	1.01	1.01	1.04	1.06	1.05	1.05	1.06	1.09	1.09	1.07	1.07	1.08	1.05	1.09
Italy	BD	1.00	1.00	1.00	0.99	1.00	0.99	0.99	0.99	0.99	0.98	0.98	0.98	0.96	0.91	0.89	0.89	0.85	0.83	1.00	0.89
	GD	0.95	0.96	0.96	0.96	0.97	0.98	0.96	0.95	0.95	0.96	0.98	0.99	0.98	0.96	0.97	0.98	0.96	0.96	0.98	0.99
	EFF	0.95	0.96	0.96	0.96	0.97	0.98	0.97	0.96	0.96	0.98	1.00	1.02	1.03	1.05	1.08	1.10	1.13	1.16	0.98	1.11
Netherlands	BD	1.00	0.97	0.97	0.94	0.93	0.91	0.93	0.92	0.92	0.89	0.89	0.88	0.89	0.88	0.90	0.91	0.88	0.89	0.96	0.89
	GD	0.80	0.80	0.81	0.82	0.84	0.85	0.85	0.86	0.87	0.88	0.89	0.89	0.89	0.88	0.92	0.92	0.92	0.93	0.94	0.93
	EFF	0.80	0.82	0.84	0.87	0.91	0.93	0.92	0.93	0.95	0.99	1.00	1.01	1.00	1.00	1.03	1.01	1.05	1.05	0.98	1.05
Nigeria	BD	0.47	0.47	0.47	0.51	0.85	1.00	1.00	0.84	0.92	1.00	0.84	0.71	0.71	0.51	0.56	0.60	0.62	0.57	0.52	0.51
	GD	0.69	0.67	0.70	0.70	0.67	0.78	0.71	0.63	0.95	1.00	0.88	0.76	0.81	0.72	0.70	0.78	0.80	0.80	0.77	0.79
	EFF	1.45	1.42	1.48	1.36	0.79	0.78	0.71	0.76	1.03	1.00	1.04	1.07	1.14	1.42	1.25	1.29	1.29	1.39	1.47	1.54
Norway	BD	0.84	0.87	0.88	0.92	0.90	0.93	0.88	1.00	0.95	0.94	0.96	0.95	0.98	1.00	1.00	0.92	0.94	1.00	1.00	0.96
	GD	1.00	0.93	0.91	0.92	0.97	0.98	1.00	1.00	1.00	1.00	1.00	1.00	0.97	0.96	0.99	0.98	0.97	0.96	0.98	1.00
	EFF	1.20	1.07	1.03	1.00	1.08	1.05	1.14	1.00	1.05	1.07	1.04	1.05	0.99	0.96	0.99	1.07	1.04	0.96	0.99	1.04
Portugal	BD	1.00	0.98	0.98	1.00	0.97	0.96	0.99	0.95	0.96	0.97	0.93	0.92	0.87	0.87	0.80	0.84	0.90	0.95	1.00	0.94
	GD	0.77	0.72	0.67	0.65	0.65	0.66	0.67	0.71	0.72	0.72	0.75	0.75	0.75	0.78	0.81	0.88	0.98	1.00	1.00	0.96
	EFF	0.77	0.73	0.69	0.65	0.68	0.69	0.68	0.75	0.75	0.74	0.80	0.81	0.87	0.89	1.01	1.04	1.08	1.05	1.00	1.02
Spain	BD	0.89	0.90	0.88	0.91	0.90	0.89	0.91	0.90	0.91	0.93	0.92	0.93	0.88	0.84	0.79	0.80	0.79	0.75	0.90	0.80
	GD	0.73	0.71	0.70	0.70	0.70	0.72	0.72	0.71	0.70	0.71	0.72	0.74	0.74	0.73	0.74	0.77	0.79	0.81	0.81	0.77
	EFF	0.82	0.79	0.79	0.77	0.78	0.81	0.78	0.79	0.77	0.76	0.79	0.79	0.84	0.88	0.94	0.96	1.00	1.07	0.89	0.97
Sweden	BD	0.74	0.56	0.65	0.50	0.48	0.49	0.61	0.57	0.54	0.48	0.45	0.44	0.45	0.42	0.46	0.47	0.42	0.40	0.45	0.43
	GD	0.80	0.81	0.79	0.77	0.76	0.75	0.78	0.78	0.79	0.79	0.80	0.80	0.79	0.79	0.82	0.82	0.81	0.82	0.82	0.84
	EFF	1.08	1.46	1.20	1.55	1.59	1.53	1.28	1.38	1.48	1.64	1.77	1.84	1.77	1.86	1.76	1.75	1.93	2.04	1.82	1.94
Switzerland	BD	0.73	0.75	0.75	0.72	0.70	0.73	0.70	0.69	0.69	0.70	0.68	0.64	0.65	0.65	0.63	0.60	0.61	0.62	0.63	0.62
	GD	0.92	0.91	0.90	0.90	0.91	0.92	0.92	0.93	0.92	0.94	0.94	0.96	0.97	0.99	1.00	1.00	0.98	0.99	1.00	1.00
	EFF	1.27	1.22	1.20	1.24	1.30	1.26	1.32	1.35	1.35	1.33	1.39	1.51	1.50	1.50	1.59	1.65	1.62	1.59	1.59	1.62
United Kingdom	BD	1.00	0.98	0.96	0.95	0.96	0.97	0.94	0.95	0.94	0.94	0.95	0.95	0.95	0.93	0.94	0.91	0.92	0.91	1.00	0.91
	GD	0.83	0.87	0.86	0.87	0.88	0.91	0.92	0.93	0.94	0.95	0.95	0.95	0.97	1.00	0.99	1.00	1.00	1.00	1.00	1.00
	EFF	0.83	0.88	0.89	0.91	0.92	0.95	0.97	0.99	1.00	1.01	1.00	1.00	1.01	1.07	1.06	1.10	1.09	1.10	1.00	1.10

Source: Author Computation, data from various sources

Ta**ble 4.4b:** Environmental Efficiency in Nigeria in relation to Asia

	Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
China	BD	1.00	1.00	0.94	0.91	0.89	0.88	0.87	0.93	0.97	0.98	1.00	0.99	0.99	0.94	0.98	1.00	1.00	1.00	1.00	0.96
	GD	0.76	0.78	0.74	0.75	0.76	0.74	0.71	0.66	0.65	0.64	1.00	1.00	1.00	0.95	0.98	1.00	1.00	1.00	1.00	1.00
	EFF	0.76	0.78	0.79	0.83	0.86	0.84	0.82	0.71	0.67	0.65	1.00	1.01	1.01	1.01	1.00	1.00	1.00	1.00	1.00	1.04
Hong Kong	BD	0.85	1.00	0.91	0.85	0.93	0.82	0.93	1.00	0.97	1.00	0.91	0.88	0.91	0.83	0.87	0.88	0.89	0.95	0.88	0.89
	GD	0.91	1.00	0.81	0.88	0.88	0.86	0.90	0.92	0.97	1.00	1.00	1.00	1.00	1.00	1.00	0.98	0.97	1.00	0.98	1.00
	EFF	1.07	1.00	0.88	1.04	0.95	1.04	0.97	0.92	1.00	1.00	1.10	1.13	1.10	1.21	1.14	1.12	1.08	1.06	1.11	1.12
	BD	0.90	0.86	0.80	0.79	0.83	0.75	0.75	0.73	0.71	0.71	0.72	0.72	0.77	0.78	0.73	0.75	0.78	0.76	0.75	0.73
	GD	0.87	0.85	0.84	0.86	0.90	0.85	0.88	0.88	0.79	0.76	0.97	0.91	0.94	0.96	0.92	0.88	0.91	0.91	0.88	0.89
	EFF	0.96	0.99	1.05	1.09	1.09	1.12	1.17	1.19	1.11	1.06	1.36	1.26	1.22	1.24	1.27	1.18	1.17	1.20	1.17	1.22
Indonesia	BD	0.52	0.55	0.46	0.52	0.52	0.56	0.56	0.58	0.57	0.56	0.55	0.59	0.63	0.64	0.58	0.77	0.78	0.62	0.67	0.67
	GD	0.58	0.57	0.65	0.75	0.71	0.70	0.71	0.74	0.70	0.69	0.81	0.82	0.82	0.83	0.79	0.88	0.87	0.78	0.79	0.79
	EFF	1.11	1.03	1.41	1.44	1.37	1.25	1.27	1.28	1.23	1.23	1.48	1.39	1.30	1.31	1.36	1.14	1.11	1.25	1.18	1.18
Japan	BD	0.95	0.94	0.91	0.94	0.96	0.94	0.96	0.98	1.00	0.98	0.97	0.99	0.96	0.89	0.95	0.97	1.00	1.00	0.98	0.95
	GD	0.95	0.95	0.96	0.94	0.95	0.96	0.97	0.99	1.00	1.00	0.98	0.99	0.98	0.96	1.00	1.00	1.00	1.00	1.00	1.00
	EFF	1.00	1.01	1.06	1.00	0.99	1.02	1.01	1.01	1.00	1.02	1.01	1.01	1.02	1.07	1.05	1.03	1.00	1.00	1.02	1.05
Korea, Rep.	BD	0.96	0.98	0.89	0.93	0.96	0.96	0.96	0.95	0.96	0.91	0.91	0.93	0.94	0.94	0.99	1.00	0.99	0.99	0.92	0.97
	GD	0.53	0.57	0.68	0.70	0.69	0.71	0.71	0.71	0.72	0.73	0.93	0.95	0.95	0.95	0.99	1.00	1.00	1.00	0.95	0.97
	EFF	0.55	0.59	0.77	0.76	0.71	0.74	0.75	0.75	0.75	0.81	1.01	1.01	1.01	1.01	1.00	1.00	1.01	1.01	1.03	1.00
Nigeria	BD	0.40	0.38	0.41	0.47	0.74	1.00	1.00	0.73	0.88	1.00	0.69	0.52	0.51	0.33	0.35	0.38	0.38	0.34	0.30	0.30
	GD	0.70	0.69	0.71	0.71	0.69	0.78	0.72	0.68	0.97	1.00	1.00	0.90	0.96	0.87	0.85	0.94	0.97	0.97	0.95	0.97
	EFF	1.74	1.82	1.76	1.49	0.93	0.78	0.72	0.93	1.10	1.00	1.45	1.74	1.86	2.67	2.44	2.47	2.53	2.84	3.18	3.20
Singapore	BD	0.90	1.00	0.91	0.87	0.84	0.74	0.75	0.50	0.43	0.44	0.42	0.29	0.46	0.54	0.54	0.46	0.66	0.60	0.55	0.56
	GD	0.78	0.83	0.78	0.84	0.89	0.83	0.88	1.00	1.00	1.00	1.00	1.00	0.92	0.89	0.97	0.94	1.00	0.98	0.96	1.00
	EFF	0.87	0.83	0.86	0.96	1.06	1.11	1.17	1.99	2.34	2.25	2.38	3.43	2.00	1.65	1.79	2.05	1.53	1.62	1.77	1.80

Source: Author Computation, data from World Bank World Development Indicators (WDI)

4.4 Effect of Environmental Efficiency on Bilateral Trade between Nigeria and HerTop Trading Partners

The influence of environmental efficiency on bilateral trade between Nigeria and her top trading partners EU+2 and Asia is investigated at both aggregate and disaggregate levels. The results are presented in turn in what follows.All diagnostics statistics indicate that the estimated models are appropriate and the estimates are valid. For instance, the R-square statistics show that about 83% (54%) and 70% (62%) of the changes in total import and total export respectively between Nigeria and EU+2 (Asia) are accounted for by all the explanatory variables. Further diagnostics on the aggregate models show that the Wald Chi square test reject the null hypothesis that all explanatory variables are simultaneously equal to zero, thus each variable is important in the model. For sectoral models, likelihood ratio statistics are significant which confirms the fitness of the estimated models. Other statistics, such as Pseudo R square, Alkaike Information Criteria (AIC) and Bayesian Information Criteria (BIC), are similarly reported.

4.4.1 Impact of Environmental Efficiency on Aggregate Imports and Exports of Nigeria to the EU+2 and Asia

The random effect GLS and Arellano-Bond Dynamic GMM results of the effect of environmental efficiency on total import and export between Nigeria and her top partners in the EU+2 and Asia are reported in Tables4.5a and 4.5b.Estimates of the random effect GLS are interpreted due to their robustness in the presence of heteroscedasticity as reported by the Breusch-Pagan/Cook-Weisberg statistics in the Table. Results show that the effect of environmental efficiency in the EU+2 on Nigeria’s import from the Union is positive but insignificant. However, such efficiency in Nigeria exerted significant positive effect on import of the country from the EU+2, as 1% increase in environmental efficiency raised total import from the EU+2 by about 1.46%. Moreover, the results show that bilateral trade agreement significantly promoted Nigeria’s import from the EU+2, industrialization in the partners’ economies reduced Nigeria’s import significantly while the influence of industrialization in Nigeria on such import is negligible. When environmental efficiency interacts with bilateral trade agreement and industrialization in the economies of the EU+2 top partners, import of Nigeria from the EU+2 top partners could not be promoted significantly. Thus, industrialization in these economies could not enhance the influence of environmental efficiency on such import.

Results for other variables in the gravity model are largely similar for both import models. For instance, common language exerted significant positive influence on Nigeria's import from top partners in the EU+2. In the same vein, GDP per capita (income) of Nigeria's EU+2 top partners, and real effective exchange rate in Nigeriaare significantly drivers of the country's import from the EU+2. thus, higher income per capita in the EU+2 and improvement in the real value of naira relative to other currencies is important for Nigeria's total import from the EU+2. However, while resource endowmentin Nigeria is a significant driver of import of the country from the EU+2, the presence of this factor in the partners' countries significantly hindered such import. Other factors such as common colonial ties, distance as well as resource endowment in the EU+2 significantly reduced Nigeria's import from this region.

For the total export model, environmental efficiency in Nigeria contributed significantly to her export to the EU+2 with elasticity of 2.89. However, environmental efficiency in the economies of the top trading partners does not significantly promote Nigeria's total export to the region. This implies that the EU+2 may not appreciably increase their commodity import from Nigeria when they consider their environmental efficiency status relative to that of Nigeria. Thus, as Nigerian firms become environmentally friendly in their production activities, the associated cost of adjustment tends to reduce in the long-run, raising workers health status and productivity and enhancing competitiveness and export. However, although the income effect is weak, import is significant raised as environmental efficiency increases in Nigeria.Further, bilateral trade agreement between Nigeria and the EU+2 partners exerted significant influence on total export of Nigeria to the EU+2 but the effect of industrialization on such export is negligible. The interaction of the efficiency scores bothfor Nigeria and the partners in the EU+2 with bilateral trade agreement, as well as industrialization could not raise Nigeria's export to the EU+2 significantly. This suggest that a consideration for environmental efficiency status of Nigeria, as well as those of the EU+2 partners, may jeopardize any potential effect that trade agreements between EU+2countries and Nigeria and industrialization in the EU+2 exert on Nigeria's total export to the EU+2.

Further results suggest that while Nigeria's total export to top partners in the EU+2 decreased with increasing distance, common language and GDP per capita (income) of EU+2 partners significantly contributed to increase in Nigeria's total export to members of the Union. Also, resource endowment and real effective exchange rate in the economies of Nigeria's top EU+2 partners, GDP per capita in Nigeria and common colonial ties hindered the country's total export to the EU+2 significantly.

Regarding the results of the effect of environmental efficiency on total import and export between Nigeria and her top partners in Asia, estimated models are appropriate and estimates are largely reliable (Table 4.4). According to the R-square statistics, 54% and 62% of the changes in total import and total export respectively between Nigeria and Asia are explained by all the explanatory variables. Moreover, the Wald Chi square test rejects the null hypothesis that all explanatory variables are simultaneously equal to zero, confirming the importance of each variable in the model.

Results obtained from the import model revealthat environmental efficiency in Nigeria and those of her top Asian partners had significant positive impact on the country's total import from Asia with elasticities of about 1.72 and 1.68 respectively. Thus, the more environmentally efficient Nigeria and her trading partners in Asia become, the higher the volume of Nigeria's import from Asia.

Moreover, results reveal that the level of industrialization in the economies of Nigerian trading partners in Asia is a significant driver of the country's total import from Asia but its interaction with environmental efficiencies in Nigerian and Asia did not yield any significant influence. This underscores the positive contribution of the recent wave of industrialization in Asia to Nigeria's total import given the large variety of China products in the country. However, when environmental efficiency (Nigeria and Asia) is considered in the face of the surge of industrial activities in China, the influence on Chinese export to Nigeria may be very infinitesimal. The impact of common colonial ties and distance on Nigeria's total import from China is significant but negative while all other gravity variables did not impact such import significantly.

For exports, estimates show that the effect of environmental efficiency, either in Nigeria or in Asian partner economies, on Nigeria's total export from Asian top partners is not significant. This suggests that an improvement in environmental efficiency among Nigeria's top trading partners in Asia may have very infinitesimal influence on the country's total export to these partners especially as these partners disregard efficiency in other economies.

Results further show that industrialization in Asian partners' economies (and in Nigeria), as well as its interaction with environmental efficiency in Nigeria and Asia, did not affect the country's total export significantly. This reflects the non-competitive nature of Nigerian products in Asian economies given the wave of industrialization and rising focus on renewable energy sources in powering such increased industrial activities. As in Nigeria's import from Asia, the country's total export to her top trading partners in Asia is significantly and negatively affected by distance and common colonial relations while other variables such as GDP per capita, resource endowment and real effective exchange rate in both economies of Nigeria and her Asian partners, as well as common language did not significantly contribute to such export.

Estimates confirm that environmental efficiency in Nigeria is important for bilateral trade between Nigeria and her top trading partners in the EU+2. This suggests that the theoretical income effect of environmental efficiency on trade is strong for the case of Nigeria's bilateral trade with the EU+2. In essence, as Nigerian firms become environmentally innovative in their production processes, the associated cost reductions enhance their competitiveness in the EU+2 markets. This is particularly possible in the medium to long-run where firms have fully adjusted their production processes to embrace low carbon practices that eliminates environmental tax, promotes clean environment and healthy workers, increases output and enhances environmental quality of products that competes favourably in the export market. Increased foreign exchange, arising from the higher export, implies higher income which is increasingly used to finance imports. In the same vein, the more environmentally inefficient the country is, the less competitive she becomes, reducing total export to the EU+2 in the process. This is consistent with Doganay et al (2014) where countries that improve theirenvironmental efficiency are found to experience strong international trade effects, boththrough increased exports and increased imports. On the contrary, environmental efficiency in the economies of Nigeria's top EU+2 trading partners does not matter for the country's total trade(import and export)with the EU+2. This is found to contradict the submission of Doganay et al (2014) where efficiency in the partner country is found to be major drivers of a country's export.Although, most of the selected Nigeria's EU+2 partners are highly committed to carbon reduction with very low carbon pricing gap, trade with Nigeria is largely driven by bilateral trade agreements rather than environmental consideration.

For bilateral trade activities between Nigeria and her top trading partners in Asia, estimates indicate that while environmental efficiency in Nigeria promotes total import from Asia, it is not important from her export to the region. While this may contradict Costantini and Crespi (2008) where environmental regulation is discovered to have significant positive effect on exports, it further reinforces the income effect found by Doganay et al (2014). Higher incomes from exports to the EU+2 engendered by improvement in environmental efficiency in Nigeria increases the ability to import from top partners both in the EU+2 and Asia. In essence, environmental inefficiency in Nigeria may reduce export, foreign exchange and the ability to finance import from the EU+2 and Asia. However, while environmental efficiency in the economies of Nigeria's top partners in Asia promotes the country's import from Asia, it does not matter for her export to the region. Thus, as Nigeria's top partners in Asia becomes increasingly aware of their environment and takes conscious effort to improve environmental efficiency of production processes, their total export to Nigeria may be greatly enhanced but their import from Nigeria may remain unaffected.

Table 4.5a. Results for the Effect of Environmental Efficiency on the Total Nigeria-EU+2 Trade

Variable	Import		Export	
	Random Effect GLS	GMM	Random Effect GLS	GMM
IMP(-1)/EXP(-1)	-	-0.016(0.063)	-	-0.461(0.091)*
LAN_{NJ}	6.003(0.250)*	3.549(0.396)*	5.667(0.566)*	4.163(1.079)*
COL_{NJ}	-4.277(0.335)*	-2.149(0.557)*	-4.926(0.759)*	-4.125(1.387)*
BTA_{NJ}	6.295(0.276)*	6.727(1.458)*	5.563(0.626)*	9.717(4.288)**
DIS_{NJ}	-8.671(0.616)*	-2.524(0.733)*	-16.617(1.397)*	-6.013(2.078)*
GDP_J	9.702(0.692)*	2.240(0.869)*	8.094(1.568)*	-0.984(2.310)
RE_J	-1.813(0.463)*	-0.049(0.263)	-2.778(1.049)*	-0.749(0.732)
ER_J	-0.659(1.497)	0.495(0.717)	-9.019(3.393)*	-0.599(2.131)
IND_J	-3.638(1.352)*	0.878(0.089)*	-1.092(3.063)	1.480(0.259)*
GDP_N	0.425(1.165)	1.421(1.270)	-5.462(2.641)**	9.458(3.567)*
ER_N	3.802(1.138)*	-0.563(1.693)	0.636(2.579)	-12.768(4.701)*
IND_N	1.677(1.130)	-	1.658(2.561)	-
RE_N	0.823(0.345)**	-0.176(0.291)	0.397(0.783)	-0.112(0.852)
EF_J	0.682(2.109)	0.850(0.394)**	5.567(4.780)	2.379(1.125)**
EF_N	1.461(0.591)*	-5.735(1.340)*	2.891(1.340)**	5.340(3.215)***
$INDEF_J$	-	-	-	-
$BTAEF_J$	-2.125(2.332)	-	-7.691(5.285)	-
$BTAEF_N$	-1.234(0.662)***	-0.993(0.307)*	-1.726(1.500)	-1.713(0.873)**
Constant	-5.080(3.083)***	-	89.429(6.988)*	-
Observation	190	160	190	160
R Square	0.835	-	0.692	-
Wald chi Square	877.57*	157975.63*	388.23*	19856.26*
Sargan	-	150.03	-	135.17
BG/CW	3.75**	-	29.88*	-

Source: Author Computation, data from various sources; NB: Sargan = Sargan test of overidentifying restrictions; BG/CW = BrEU+2sch-Pagan / Cook-Weisberg test for heteroskedasticity

*Note: *,**,*** represent 1%, 5% and 10% level of significance respectively. Values in parenthesis are the standard errors*

Table 4.5b. Results for the Effect of Environmental Efficiency on Total Nigeria-Asia Trade

Variable	Import		Export	
	Random Effect GLS	GMM	Random Effect GLS	GMM
IMP(-1)/EXP(-1)		-0.893(0.121)*	-	-0.298(0.125)*
LAN_{NJ}	0.511(0.383)	-3.773(1.471)*	0.035(0.486)	1.818(1.542)
COL_{NJ}	-4.421(0.480)*	-5.928(0.811)*	-4.246(0.609)*	-2.029(2.252)
BTA_{NJ}	-	-	-	-
DIS_{NJ}	-9.075(1.073)*	8.292(1.309)*	-11.246(1.362)*	1.880(11.146)
GDP_J	4.360(6.617)	-1.720(0.249)*	9.458(8.398)	-0.170(1.263)
RE_J	-1.397(2.614)	-	0.318(3.317)	0.362(0.413)
ER_J	0.321(1.364)	1.078(0.764)	0.452(1.731)	-2.215(1.441)
IND_J	6.575(4.007)***	-0.223(0.289)	-6.567(5.084)	0.800(1.304)
GDP_N	-3.965(2.629)	-	-1.267(3.336)	-
ER_N	0.856(2.402)	-	0.167(3.049)	-
IND_N	2.460(2.262)	-	-2.167(2.871)	-
RE_N	-0.988(0.855)	-	-0.586(1.085)	-
EF_J	1.725(0.553)*	2.706(0.306)*	0.040(0.702)	-2.540(1.511)***
EF_N	1.683(0.861)**	3.260(1.721)**	1.719(1.093)	4.207(18.771)
$INDEF_J$	-0.727(1.287)	-	-0.957(1.634)	-
$BTAEF_J$	-	-	-	-
$BTAEF_N$	-	-	-	-
Constant	90.256(10.266)*	-	118.615(13.028)*	-
Observation	133	100	133	100
R Square	0.534	-	0.627	-
Wald chi Square	198.61*	41543.03*	135.44*	12364.46*
Sargan	-	91.73	-	85.79
BG/CW	37.02*	-	1.44	-

Source: Author Computation, data from various sources; NB: Sargan = Sargan test of overidentifying restrictions; BG/CW = BrEU+2sch-Pagan / Cook-Weisberg test for heteroskedasticity

*Note: *,**,*** represent 1%, 5% and 10% level of significance respectively. Values in parenthesis are the standard errors.*

4.4.2 Effect of Environmental Efficiency on Nigeria'sBilateral Imports and Export of Mineral Products to the EU+2 and Asia

The results of the effect of environmental efficiency on bilateral trade in mineral products between Nigeria and her top trading partners in the EU+2 and Asia are presented in Table 4.6. The results show that the effect of environmental efficiency in Nigeria on mineral import of the country from her partners in the EU+2 is significant positive with elasticity of 0.76, while the effect of this efficiency in the EU+2 is insignificant. Thus, 1.0% improvement in environmental efficiency in Nigeria contributed about 0.76% to the increase in the country's mineral import from the EU+2. Further results show that BTA had strong significant positive impact on Nigeria's mineral import from the Union but its interaction with environmental efficiency in Nigeria produced significant negative effect.

For other gravity variables, language, resource endowment in both partner's economies and exchange rate in Nigeria exerted significant positive effect on Nigeria's import from the EU+2. Thus, common language, which indicates strong social ties that facilitate trade, and abundance of productive resources, which enhances specialization, promotes Nigeria's import from the Union. This import continues to increase in the face of increasing exchange rate as Nigerian economy is highly dependent on imported petroleum product. In contrast, common colonial ties, distance and industrialization in the EU+2 had significant negative impact on Nigeria's mineral import from the EU+2. This suggests that common colonial attachment may be inimical to business while import tends to decrease with the EU+2 partners farther away. Industrialization in the EU+2 may also encourage expansion of mineral product market even within the EU+2 to power industrial activities, which may discourage export of such products to Nigeria. Other variables do not have significant effect on mineral import of Nigeria from the EU+2.

Mineral products export from Nigeria to the EU+2 is significantly and positively affected by environmental efficiency in Nigeria and in the EU+2 partners' economies with elasticities 0.55 and 3.30 respectively. Moreover, BTA and its interaction with environmental efficiencies (Nigeria) is significant (positive) in influencing Nigeria's mineral export to the EU+2. This implies that bilateral agreements between Nigeria and most of the EU+2 partners, such as the Generalized Scheme of Preferences (GSP) and

ACP-EU+2 agreement, are important drivers of Nigeria's mineral product export to the EU+2. Also, the presence of such BTA strengthens the effect of environmental efficiency in Nigeria on her mineral export to the EU+2.

Also, GDP per capita in the selected EU+2 economies had significant positive effect on export of mineral products to the EU+2 by Nigeria but the effect of Nigeria's GDP per capita is significant negative. Thus, while EU+2 GDP per capita appear to promote their import of mineral product from Nigeria, higher income per capita in Nigeria may suggest increasing ability of the country to absorb most of the mineral products in driving industrial activities thereby reduce export of the products. Similar to mineral imports, while common language has positive effect while common colonial ties and distance exert negative effects on Nigeria's mineral export to the EU+2. The coefficients of other gravity variable remain statistically insignificant.

The results of the effect of environmental efficiency on bilateral trade in mineral products between Nigeria and her top trading partners in Asia are equally presented in Table 5.5. The validity of the estimates is confirmed by the likelihood ratio statistics. The results show that environmental efficiency in the economies of Nigeria's top trading partners in Asia has significant positive effect on Nigeria's import of mineral products from the Asian partners in both models as 1.0% improvement in such efficiency raised mineral import from Asia by about 1.78%. However, the effect of environmental efficiency in Nigeria is negligible.

Further results reveal that industrialization in Asia and Nigeria had significant positive influence on Nigeria's mineral import from Asian top trading partners. This reflects the increasing role of the wave of industrialization in Asia in Nigeria's import from the region. GDP per capita in Asia does not exert significant effect on Nigeria's import from the region but the impact of Nigeria's GDP per capita is significant negative. All other variables do not influence significantly, except common colonial ties, where significant negative effect is found.

With respect to Nigeria's export of mineral product to Asia, environmental efficiency in Nigeria, as well as in the economies of her trading partners in Asia had insignificant effect. The effect of exchange rate, common colonial ties and distance on this import is significant negative while the impact of industrialization and GDP per capita in both partners' economies, as well as all other variables remain negligible.

The results on the role of environmental efficiency in bilateral trade in mineral products between Nigeria and her top trading partners in the EU+2 show that environmental efficiency in Nigeria promotes Nigeria's mineral export and encourages its import. This may also result from the reduction in associated production (environmental) cost, especially in the long-run. This follows the theoretical income effect as proceeds from the rise in oil exports to the EU+2are increasingly used to finance import of mineral products, especially petroleum products, from the EU+2. The findings are also in line with the explanation of the extended Hechscher-Ohlin (H-O) model (Markusen et al, 1995) where environmental efficiency, brought about by tightened environmental regulation, encourages oil firms to adopt environmentally-friendly technology and further engenders comparative advantage while increasing oil export.

The results suggest that environmental efficiency in Asia is major driver of bilateral trade in mineral between Nigeria and her top partners in the region. Most of the selected partners in Asia recorded relatively high carbon emission per dollar of GDP with countries such as Japan, India, China and Indonesia having carbon pricing gap of at least 69%. However, the high export incentives in these economies as reflected by the low cost of doing business and high degree of ease with which businesses are conducted suggests that products from this region easily enters the Nigerian market,an economy with similar environmental issues and poor standard enforcement.Moreover, while such efficiency enhances Nigeria's import from her top partners in Asia, it does not influence the country's export to these partners. This may reflect the increasing search for renewable energy sources and application of clean technology associated with higher levels of environmental efficiency, which tend to reduce the demand and import for crude oil from Nigeria. On the other hand, since the main export product of Nigeria is crude oil which is of high demand by the industrialized economies with market regulated by OPEC, the insignificant effect of environmental efficiency in Nigeria on her export to top Asia trading partners is expected. Thus, environmental efficiency does not enhance the production and export of crude oil from which Nigeria has comparative advantage which appears contrary to the theoretical prediction of Markusen et al (1995) of the effect of government policy on the existing comparative advantage. Thus, in line with Doganay et al, (2014), environmental efficiencies in the economies of Nigeria’s top trading partners in the EU+2 and Asia matter for trade in mineral products between the country and these regions while such efficiency in Nigeria is important for mineral trade only between the country and her partners in the EU+2.

Table 4.6. Negative Binomial Regression Results for the Effect of Environmental Efficiency on Bilateral Trade in Mineral Products

Variables	**Nigeria-EU+2**		**Nigeria-Asia**	
	Import	Export	Import	Export
LAN_{NJ}	1.387(0.138)*	0.837(0.119)*	0.351(0.230)	-0.020(0.177)
COL_{NJ}	-0.877(0.176)*	-0.653(0.155)*	-1.571(0.323)*	-2.416(0.272)*
BTA_{NJ}	1.206(0.157)*	0.827(0.132)*	-	-
DIS_{NJ}	-1.096(0.346)*	-2.158(0.294)*	-0.657(0.810)	-5.593(0.608)*
GDP_{J}	0.256(0.378)	0.849(0.312)*	-0.526(4.937)	-0.495(4.172)
RE_{J}	0.608(0.252)**	-0.162(0.205)	-0.819(1.796)	-0.390(1.394)
ER_{J}	-0.369(0.792)	-0.963(0.697)	0.343(0.906)	-0.119(0.693)
IND_{J}	-1.446(0.701)**	-0.022(0.614)	5.927(2.941)**	-2.450(2.462)
GDP_{N}	0.141(0.591)	-0.878(0.542)***	-2.669(1.734)	0.297(1.321)
ER_{N}	1.458(0.578)*	-0.001(0.512)	0.218(1.522)	-2.052(1.224)***
IND_{N}	0.693(0.570)	0.475(0.509)	2.588(1.443)***	-0.749(1.129)
RE_{N}	0.287(0.171)***	-0.022(0.156)	-0.488(0.578)	0.298(0.440)
EF_{J}	1.443(1.427)	3.295(1.216)*	1.782(0.349)*	-0.532(0.344)
EF_{N}	0.764(0.371)**	0.550(0.306)***	0.716(0.556)	-0.613(0.441)
$INDEF_{J}$	-	-	-0.840(0.749)	1.121(0.796)
$BTAEF_{J}$	-2.000(1.528)	-3.858(1.304)	-	-
$BTAEF_{N}$	-0.645(0.391)***	-0.449(0.330)*	-	-
Constant	1.617(1.742)	12.486(1.494)*	0.542(7.606)	57.713(6.030)*
LR chi square	151.94*	130.85*	47.05*	104.90*
Pseudo R square	0.134	0.106	0.067	0.120
AIC	1017.99	1138.45	691.36	803.90
BIC	1076.43	1196.90	737.60	850.15

Source: Author Computation, data from various sources (Table 4.1)

*Note: *,**,*** represent 1%, 5% and 10% level of significance respectively. Values in parenthesis are the standard errors.*

4.4.3 Effect of Environmental Efficiency on Nigeria's Bilateral Imports and Export of Non-Mineral Products to the EU+2 and Asia

Table 4.7 reports the results of the effect of environmental efficiency on bilateral trade in non-mineral products between Nigeria and her top trading partners in EU+2, including the likelihood ratio statistics that indicate that the estimates are appropriate. Estimates reveal that the coefficients of environmental efficiency in Nigeria and in the EU+2 are insignificant. Moreover, BTA exerted significant positive effect on Nigeria's non-mineral import from and export to the EU+2 as 1.0% improvement in such agreement increased Nigeria's non-mineral import and non-mineral export to the EU+2 by 0.51% and 0.53% respectively. This may reflect the increasing role of BTA in promoting trade relations, especially in non-mineral products between Nigeria and the EU+2. In the same vein, common language had significant increasing impact on non-mineral trade (import and export) between the two trading partners. Also, while GDP per capita in the EU+2 partners' economies had significant positive effect on Nigeria's import of non-mineral products from the region with elasticity of 0.59, real effective exchange rate in Nigeria significantly raised the country's export to the region by about 0.78%.

Table 5.6 equally presents the results of the effect of environmental efficiency on bilateral trade in non-mineral products between Nigeria and her top trading partners in Asia. Similar to the results for Nigerian-EU+2 trade in non-mineral, the effect of environmental efficiency on non-mineral import from and export to Asia top partners is insignificant. This may indicate that environmental issues do not matter for trade activities between the partners. Further results show that common colonial ties and distance significantly influence Nigeria's import from Asia rather than export to the region, as import significantly fall with increasing distance and level of colonial attachment. All other variables, including industrialization, remain negligible in their impact on Nigeria's trade with her top trading partners in Asia.

Findings in terms of non-mineral trade suggest that such efficiency may not matter for trade (import and export) in non-mineral products between Nigeria and her top trading partners in the EU+2 and Asia, which is contrary to the postulation of the Neo-classical trade theory as evident in the H-O model extended to the role of government policies in trade by Markusen et al (1995). These results largely reflect the fact that most firms in Nigeria do not consider the environmental implication of the production activities which is further worsened by the lax and poor enforcement of environmental regulations. This may be particularly dominant in the short-medium run as firms prefer to pay high environmental costs, reduce output without significant changes in the level of competitiveness. Rather than complying with international environmental standards, Nigerian exporters often rely on other factors, such as incentives from BTA especially for trade with the EU+2, as more important drivers of their trade activities with their trading partners. In terms of import, results confirm that environmental efficiency is not a major consideration for the consumption of foreign commodities underscoring the flooding of the Nigerian market with substandard and pollution intensive goods.

Table 4.7. Negative Binomial Regression Results for the Effect of Environmental Efficiency on Bilateral Trade inNon-MineralProducts

Variable	Nigeria-EU+2		Nigeria-Asia	
	Import	Export	Import	Export
LAN_{NJ}	0.444(0.112)*	0.690(0.125)*	0.045(0.078)	-0.100(0.094)
COL_{NJ}	-0.229(0.147)	-0.351(0.165)**	-0.379(0.103)*	0.028(0.118)
BTA_{NJ}	0.509(0.126)*	0.533(0.141)*	-	-
DIS_{NJ}	-0.563(0.278)**	-1.038(0.318)*	-0.762(0.226)*	-0.348(0.251)
GDP_{J}	0.585(0.317)***	0.204(0.346)	0.217(1.471)	0.527(1.589)
RE_{J}	0.090(0.211)	0.241(0.231)	-0.090(0.544)	0.563(0.635)
ER_{J}	0.278(0.650)	-0.195(0.756)	0.019(0.281)	-0.065(0.339)
IND_{J}	-0.546(0.594)	-0.588(0.678)	0.601(0.895)	-0.348(0.964)
GDP_{N}	0.112(0.512)	0.219(0.564)	-0.311(0.549)	-0.531(0.628)
ER_{N}	0.554(0.500)	0.869(0.556)	0.059(0.500)	0.312(0.564)
IND_{N}	0.309(0.496)	0.559(0.546)	0.191(0.471)	0.006(0.537)
RE_{N}	0.082(0.151)	0.184(0.166)	-0.084(0.179)	-0.083(0.205)
EF_{J}	0.285(0.966)	0.490(1.200)	0.150(0.118)	-0.034(0.133)
EF_{N}	0.089(0.269)	0.256(0.317)	0.131(0.181)	0.337(0.213)
$INDEF_{J}$	-	-	-0.041(0.274)	-0.042(0.304)
$BTAEF_{J}$	-0.609(1.065)	-1.142(1.307)	-	-
$BTAEF_{N}$	-0.104(0.298)	-0.229(0.344)	-	-
Constant	-0.291(1.393)	5.980(1.621)*	9.022(2.153)*	5.696(2.405*)
LR chi square	34.01*	77.45*	30.26*	12.22
Pseudo R square	0.038	0.084	0.048	0.021
AIC	905.59	874.05	629.71	612.03
BIC	960.78	929.25	673.07	655.39

Source: Author Computation, data from various sources (Table 4.1)

*Note: *,**,*** represent 1%, 5% and 10% level of significance respectively. Values in parenthesis are the standard errors.*

4.4.4 Effect of Environmental Efficiency on BilateralNigeria's Imports and Export of Agricultural Products to the EU+2 and Asia

Regression results for the influence of environmental efficiency on bilateral trade in agricultural products between Nigeria and the EU+2 is shown in Table 4.8, including the log likelihood ratio that confirms the validity of the estimates. The coefficient of environmental efficiency in Nigeria and the EU+2 is statistically insignificant in both import and export models. This indicates that environmental implication of production processes in Nigeria, as well as in the EU+2 partners' economies does not matter for trade in agricultural products between Nigeria and her partners in the EU+2. This may be a result of the extremely small consumption of fossil fuel in this sector compare to other sectors such as oil and manufacturing, and the low consideration for the environment in economic activities, including trade, in Nigeria.

The results further reveal that the influence of BTA on Nigeria's import of agricultural products from the EU+2 is significant positive, while industrialization in the EU+2 had significant reducing impact on this import where elasticity is about 1.30. In the same vein, the significant increasing effect of BTA to Nigeria's export to countries in the Union suggests that about 0.81% improvement in this export is linked with 1.0% improvement in BTAs between Nigeria and top partners in the Union. These results reveal that the role of BTA may be more important for trade in agricultural products between these partners than environmental efficiency, while industrialization in the EU+2 contributes to the reduction in import from the Union as European industries are increasingly fed by the raw materials from the sector.

For other variables, common language and GDP per capita in the EU+2 had significant positive effect on Nigeria's trade (import and export) in agricultural products with the EU+2, while the influence of colonial ties and distance is significant negative. Hence, while 1.0% increase in GDP per capita in the EU+2 promoted Nigeria's agricultural import up to 1.06% and export up to 0.70%, a similar increase in distance could cause import of these products to fall by about 1.04% and export by 1.84%. The coefficients of all other variables, including interaction of industrialization and BTA with environmental efficiency, remain statistically insignificant, suggesting that their influence on trade in agricultural products between Nigeria and the EU+2 is infinitesimal.

Table 5.7 also reports the results for the effect of environmental efficiency on bilateral trade in agricultural products between Nigeria and Asia. Environmental efficiency in Nigeria and Asia had significant positive effect on Nigeria's import from Asian top trading partners. Agricultural import from Asia rose by 0.74% or 0.65% in response to 1.0% improvement in environmental efficiency in Nigeria or Asia respectively. This implies that improvement in environmental efficiency in Nigeria, as well as in the economies of her top partners in Asia, enhances the country's import of agricultural products from these partners.

GDP per capita in Nigeria exert negative and significant effect on Nigeria's agricultural imports from Asia with elasticity of about 1.97, but the impact of industrialization in Asia is significant positive with elasticity of about 2.92. This reflects the increasing substitution of foreign input for domestic ones despite rising incomes, as well as the positive role of industrialization in import of agricultural products in Nigeria. In contrast, common colonial relationship and distance exhibit significant negative effect on import of agricultural products by Nigeria from Asia. All other variables do not significant influence this import.

The influence of environmental efficiency, both in Nigeria and in the economies of her trading partners in Asia, on her export of agricultural products to Asia is insignificant. Moreover, while language and distance exert significant negative effect on Nigeria's agricultural export to Asia as serves as barriers to this export, colonial ties had positive impact and could promote the export. The coefficients of other variables remain insignificant.

Estimates from the effect of environmental efficiency on Nigeria's trade in agricultural products with the EU+2 reveal that environmental efficiency, either in Nigeria or in the EU+2, do not significantly influence trade between them. However, the role of BTA is vital as it creates incentives for facilitate trade relations between the country, alongside other developing countries, with countries in the EU+2. This finding also does not corroborate Markusen et al (1995) on the role of government policy in trade. For the case Nigeria-Asia trade relations, environmental efficiency in Nigeria and Asia is found to promote Nigeria's agricultural import from Asia, but largely indifferent in its effect on export to the same region. Thus, the more both partners are able to reduce environmental costs arising from the adoption of low carbon production techniques in the agricultural sector, the greater the volume of import of agricultural products of Nigeria from her top partners in Asia. This is partly supported by Doganay et al (2014) where environmental efficiency is found to enhance both export and import.

Table 4.8. Negative Binomial Regression Results for the Effect of Environmental Efficiency on Bilateral Trade in AgriculturalProducts

Variable	Nigeria-EU+2		Nigeria-Asia	
	Import	Export	Import	Export
LAN_{NJ}	0.778(0.127)*	1.114(0.138)*	-0.027(0.106)	-0.686(0.159)*
COL_{NJ}	-0.389(0.167)*	-0.678(0.181)*	-0.749(0.147)*	0.675(0.184)*
BTA_{NJ}	0.682(0.149)*	0.805(0.158)*	-	-
DIS_{NJ}	-0.939(0.322)*	-1.635(0.356)*	-2.307(0.284)*	-1.118(0.306)*
GDP_J	0.937(0.372)*	0.472(0.376)	0.010(2.073)	2.926(2.057)
RE_J	0.177(0.248)	0.078(0.249)	-0.068(0.671)	-0.235(0.816)
ER_J	0.083(0.733)	0.092(0.837)	0.058(0.363)	0.306(0.486)
IND_J	-1.295(0.685)***	-0.612(0.745)	2.831(1.287)**	-0.042(1.255)
GDP_N	0.593(0.577)	0.314(0.608)	-1.966(0.729)*	-0.613(0.830)
ER_N	0.846(0.566)	0.844(0.602)	0.135(0.622)	0.598(0.749)
IND_N	0.582(0.561)	0.549(0.588)	0.274(0.609)	0.526(0.704)
RE_N	0.095(0.171)	0.191(0.179)	-0.551(0.233)**	-0.026(0.267)
EF_J	-0.196(1.068)	1.005(1.422)	0.736(0.151)*	0.006(0.176)
EF_N	-0.075(0.293)	0.191(0.351)	0.647(0.247)*	0.254(0.273)
$INDEF_J$	-	-	-0.144(0.338)	-0.403(0.393)
$BTAE_J$	-0.381(1.193)	-1.707(1.533)	-	-
$BTAEF_N$	-0.190(0.324)	-0.222(0.376)	-	-
Constant	-2.192(1.637)	9.332(1.829)*	20.297(2.615)*	12.053(2.907)*
LR chi square	76.24*	151.74*	124.81*	70.72*
Pseudo R square	0.080	0.153	0.169	0.107
AIC	906.49	874.72	645.21	617.51
BIC	961.69	933.17	691.45	660.87

Source: Author Computation, data from various sources (Table 4.1)
*Note: *,**,*** represent 1%, 5% and 10% level of significance respectively. Values in parenthesis are the standard errors.*

4.4.5 Effect of Environmental Efficiency on Nigeria'sBilateral Imports and Export of Manufactures to the EU+2 and Asia

For bilateral trade in manufacturing products between Nigeria and the EU+2, the influence of environmental efficiency is shown in Table 4.9. The results show that environmental efficiency in Nigeria, as well as in the economies of the top partners in the EU+2, does not contribute significantly to bilateral trade in manufacturing products between Nigeria and the EU+2. This shows that environmental and health concerns are less considered for manufacturing trade activities between these partners. This may reflect the dominance of crude oil in Nigeria's export to the EU+2 while other factors may matter more for trade in manufacturing products than environmental efficiency.

Bilateral trade agreement has positive and significant effect on both Nigeria's export and import of manufactures from the EU+2. Thus, BTA is an important driver of trade in manufactures between Nigeria and the EU+2, although its presence does not significantly influence the effect of environmental efficiency on trade between Nigeria and the EU+2. While the effect of common language yielded significant positive effect on Nigeria's manufacturing import from the EU+2, the impact of distance is significant negative.

Further results show that GDP in the EU+2 exert significant positive influence on manufacturing import of Nigeria to the Union as 1.0% increase in this variable raised this import by about 0.7%. As expected, real effective exchange rate had significant positive impact on Nigeria's manufacturing export to the EU+2 and not on import from the Union. All other variables could not influence manufacturing trade between Nigeria and the EU+2.

For manufacturing trade between Nigeria and her top trading partners in Asia, results are also reported in Table 5.8. The results show that environmental efficiency both in Nigeria and Asia does not exert significant effect on Nigeria's import of manufactures from her trading partners in Asia. This indicates that environmental implications of production activities, either in Nigeria or among her Asian partners, do not significantly facilitate Nigeria's import from Asia. Common colonial ties and distance had significant negative influence on manufacturing import of Nigeria from Asia in both models. Similarly, industrialization and its interaction with environmental efficiency, as well as all other explanatory variables have insignificant impact on Nigeria's import of manufactures from Asia.

In terms of Nigeria's manufacturing export to this region, the impact of environmental efficiency is significant positive. Thus, 1.0% increase in environmental efficiency in Nigeria raised Nigeria's export of manufactures to Asia by about 0.84%. However, such efficiency among Nigeria's top trading partners in Asia exert insignificant effect on Nigeria's manufacturing export to the region. Further results reveal that resource endowment in Nigeria's Asian partners' economies had significant positive impact on Nigeria's export of manufactures to Asia with elasticities of 1.48. The effect of other variables remains insignificant.

Estimates reveal that environmental efficiency in Nigeria and in the EU+2 do not matter for Nigeria's trade in manufactures with the Union, a result that fails to support either the theoretical expectation of Markusen et al (1995) or the findings of Doganay et al (2014). Although, these results are also valid for Nigeria's import of similar products from Asia, export of this products to trading partners is largely influenced by environmental efficiency in Nigeria. Thus, as environmental tax drives firms to adopt environmentally friendly techniques in the production of manufactures, cost of production fall, output increases, carbon emission falls, environmental quality of these products increase and international competitiveness is enhanced in the long-run. This is partly in line with the submission of Doganay et al (2014).

Table 4.9. Negative Binomial Regression Results for the Effect of Environmental Efficiency on Bilateral Trade in Manufactures

	Nigeria-EU+2		Nigeria-Asia	
	Import	Export	Import	Export
LAN_{NJ}	0.484(0.122)*	0.400(0.148)*	-0.005(0.082)	0.051(0.105)
COL_{NJ}	-0.234(0.159)	0.090(0.192)	-0.373(0.109)*	0.081(0.130)
BTA_{NJ}	0.597(0.136)*	0.456(0.158)*	-	-
DIS_{NJ}	-0.839(0.300)*	-1.632(0.363)*	-0.864(0.238)*	0.013(0.291)
GDP_{J}	0.711(0.340)**	0.014(0.385)	0.740(1.544)	1.447(1.769)
RE_{J}	0.041(0.226)	0.331(0.257)	-0.148(0.571)	1.483(0.761)**
ER_{J}	0.265(0.699)	-0.039(0.868)	0.052(0.294)	0.060(0.425)
IND_{J}	-0.559(0.636)	-0.928(0.773)	0.183(0.939)	-1.430(1.070)
GDP_{N}	0.130(0.550)	0.295(0.639)	-0.202(0.572)	-0.546(0.710)
ER_{N}	0.510(0.537)	1.090(0.633)***	0.084(0.525)	0.880(0.633)
IND_{N}	0.253(0.534)	0.379(0.625)	0.202(0.492)	-0.476(0.621)
RE_{N}	0.084(0.162)	0.177(0.189)	-0.044(0.187)	-0.132(0.241)
EF_{J}	0.440(1.066)	0.953(1.468)	0.088(0.125)	-0.243(0.152)
EF_{N}	0.118(0.295)	0.460(0.389)	0.096(0.189)	0.840(0.263)*
$INDEF_{J}$	-	-	-0.012(0.290)	-0.062(0.345)
$BTAEF_{J}$	-0.762(1.171)	-1.569(1.587)	-	-
$BTAEF_{N}$	-0.159(0.324)	-0.537(0.416)	-	-
Constant	0.963(1.501)	11.946(1.879)*	10.191(2.267)*	2.904(2.790)
LR chi square	36.90*	108.52*	32.92*	35.54*
Pseudo R square	0.042	0.1186	0.053	0.055
AIC	879.36	840.22	613.12	645.09
BIC	934.56	895.42	656.48	688.45

Source: Author Computation, data from various sources (Table 4.1)
*Note: *,**,*** represent 1%, 5% and 10% level of significance respectively. Values in parenthesis are the standard errors.*

4.5 Asia or the EU+2: What Effect of Environmental Efficiency is Observed?

The summary of results for the effect of environmental efficiency on bilateral trade between Nigeria and her top trading partners in the EU+2 and Asia is presented in Tables4.10a and 10b. Empirical results confirmed that, at the aggregate level, environmental efficiency in Nigeria has significant impact on import of Nigeria from both the EU+2 and Asia. At the disaggregate level however, this efficiency only matters for mineral import from the EU+2 and agricultural import from Asia. Environmental efficiency among Nigeria's top partners in the EU+2appears less important for Nigeria's mineral import from the Union while such efficiency among partners in Asia significantly influences aggregate, as well as mineral and agricultural import of Nigeria from the region.

In terms of Nigeria's export to her top partners, environmental efficiency in Nigeria promotes aggregate and mineral export to the EU+2 while this efficiency only facilitates export of manufactures to Asia. Moreover, environmental efficiency in the EU+2 provides significant impact only on mineral export of Nigeria to the EU+2 while this efficiency among Nigeria's partners in Asia does not matter for Nigeria's export to the region both at aggregate and sectoral levels. Generally, these results reveal that environmental efficiency in Nigeria drives the country's aggregate import from trade partners in the EU+2 and Asia but only promotes export to the EU+2. Thus, the income effect could be stronger for Nigeria-EU+2 total trade than Nigeria-Asia total trade. Moreover, while environmental efficiency in Nigeria does not matter for trade in non-mineral products between Nigeria and her trade partners in the EU+2 and Asia, such efficiency largely promotes Nigeria's export and import of mineral products from the EU+2. This is in line with the prediction of the neo-classical trade theory as indicated by the extended Hechscher-Ohlin model that environmental efficiency arising from the effectiveness of environmental policy tends to enhance comparative advantage already established.This may be the case as ----Nigeria largely exports crude oil and finances import of refined petroleum products through the proceeds from such export. For agricultural and manufacturing products, results suggest that environmental efficiency in Nigeria is more important for Nigeria-Asia trade than trade between Nigeria and the EU+2.

Table 4.10a. Summary of Results on the Effect of Environmental Efficiency in Nigeriaon its Bilateral Trade with the EU+2 and Asia

	Partner	Effect of Environmental Efficiency in the EU+2 and Asia	
		Import	Export
Aggregate	EU+2	-	-
	Asia	✓	-
Mineral	EU+2	-	✓
	Asia	✓	-
Non-Mineral	EU+2	-	-
	Asia	-	-
Agriculture	EU+2	-	-
	Asia	✓	-
Manufactures	EU+2	-	-
	Asia	-	-

Source: Author Computation

Table 4.10b. Summary of Results on the Effect of EU+2 and Asia's Environmental Efficiency on Nigeria's Bilateral Trade with them

	Partner	Effect of Environmental Efficiency in the EU+2 and Asia	
		Import	Export
Aggregate	EU+2	-	-
	Asia	✓	-
Mineral	EU+2	-	✓
	Asia	✓	-
Non-Mineral	EU+2	-	-
	Asia	-	-
Agriculture	EU+2	-	-
	Asia	✓	-
Manufactures	EU+2	-	-
	Asia	-	-

Source: Author Computation

CHAPTER FIVE

SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of major findings, conclusion, policy recommendations and study limitations. In particular, section 5.2 summarizes the major findings obtained from the study while sections 5.3 and 5.4 present the conclusion and policy recommendations respectively. The chapter ends with a discussion of the main limitations of the study.

5.2 Summary of Major Findings

This research investigates the role of environmental efficiency in bilateral trade between Nigeria and her top trading partners in Asia and the EU+2. The study expands the Hecksher-Ohlinmodel of international trade to provide a role for environmental efficiency in Nigeria, a resource-rich developing country, where comparative advantage is already established in the commodity produced from using the abundant resources intensively. Analysis is conducted in two stages. The first stage obtains environmental efficiency scores for each country. In the second stage analysis, the effect of environmental efficiency on bilateral trade (import and export) is examined using the efficiency scores generated.

Findings from the first stage analysis reveal that although some improvements in environmental efficiency were recorded among Nigeria's top trading partners in the EU+2 than partners in Asia, efficiency appears to vary significantly among the selected EU+2 countries than among the selected Asia countries. In Asia, Singapore appears as the most environmentally efficient partner for most of the years while Korea Republic and China are the least efficient which is in line with much of the literature. In the EU+2, results show that Spain is the most environmentally-inefficient partner. In Nigeria, environmental efficiency improved in recent years relative to both her EU+2 and Asia partners, surpassing efficiency scores of all her partners in Asia beginning from 2008.

Findings confirm that environmental efficiency in Nigeria has significantly contributes to the increase in aggregate import of Nigeria from both the EU+2 and Asia but it only promotes aggregate export to the EU+2. At the disaggregate level, environmental efficiency in Nigeria enhances bilateral trade (import and export) in mineral products between Nigeria and her trading partners in the EU+2 but encourages only agricultural import, as well as manufacturing export, from partners in Asia.Environmental efficiency in the EU+2 does not matter for Nigeria's aggregate import from the Union but facilitates aggregate export to the region. Improvement in such efficiency also produces increasing effect on bilateral trade in mineral products between Nigeria and the EU+2, while the effect on non-mineral products, including agricultural products and manufactures, is negligible. Further results reveal that while environmental efficiency in Asia increases Nigeria's aggregate import, as well as import of mineral and agricultural products from Asia, Nigeria's export of similar products, including manufactures are largely unaffected.

5.3 Conclusion

The study reveals that environmental efficiency in Nigeria promotes aggregate bilateral trade (import and export) between Nigeria and the EU+2 but only contributes to aggregate import from Asia. Such efficiency also matters for trade in mineral products between Nigeria and the EU+2, strengthening Nigeria's comparative advantage but in favour of the EU+2 rather than Asia. However, this efficiency is important for Nigeria's import of agricultural products from Asia and export of manufactures to the same region. Moreover, environmental efficiency in the EU+2 is important for Nigeria's mineral trade with the EU+2 but such efficiency in Asia is less important for the country's export to the region, both at aggregate and disaggregate, to Asia. Thus, the effect of environmental efficiency, both in Nigeria and among her partners in Asia and the EU+2, varies with the type of products traded.

5.4 Policy Recommendations

A number of policy implications are derived from the findings of this study. First, findings emphasize the importance of environmental efficiency in Nigeria in bilateral trade between Nigeria and her trading partners in Asia and the EU+2. Thus, environmental policy in Nigeria must focus on the design of pollution tax that encourages firms to be innovative in their production processes such that environmentally friendly techniques are increasingly adopted to reduce environmental implication of their activities to the minimum level per unit of output produced. This will reduce all associated costs and promote healthy workforce that technically increases output and competitiveness in the long-run, hence increases export as products meet international environmental standards.

Second, there is need for policy makers, especially the Ministry of Environment and Ministry of Industry, Trade and Investment to harmonize their policies, such that rather than focusing on mere national environmental outcomes, competitive advantage of environmental efficiency in production process should be an element of such outcomes. Third, more effort should be directed towards formulating regulations that engender environmental efficiency in the agricultural and manufacturing sectors. This becomes particularly more crucial as improvement in environmental efficiency in the EU+2 and Asiado not significantly encourage Nigerian export to her partners in these regions.

Fourth, since environmental efficiency is found to encourage total import of Nigeria from Asia and the EU+2, efforts must be put in place to sensitize the populace of the quality of domestic products in order to encourage the substitution of imported goods for domestic ones. Finally, since BTA is an important driver of bilateral trade, especially between Nigeria and her trade partners in the EU+2, Nigerian policy makers and negotiators in bilateral trade and investment agreements must be conscious of the environmental implications of such trade relations between them.

5.5 Contribution to Knowledge

The study contributes to knowledge in the following ways: First, it extended the H-O model to incorporate the role of environmental efficiency in existing comparative advantage, and hence internationals competitiveness. Second, it demonstrates empirically the influence of this efficiency (policy outcome), rather than regulation (policy) as dominant in the literature, on bilateral trade in a resource-rich developing country

(country-specific context). Lastly, it examines sectoral (mineral and non-mineral) dimensions of this relationship which has been overlooked in the literature.

5.6 Study Limitations

5.6.1 Limitation of the Study

In terms of limitation of the study, firm or product level analysis could not be undertaken as this still remains a challenge in the literature due to data constraints. Such environmental efficiency-trade link analysis requires firms in all selected countries to report the level of environmental pollution associated with their production activities along with their export and import volumes. This study therefore makes use of macro data, both at aggregate and disaggregates levels.

5.6.2 Limitation to the Study

This study only focuses on Nigeria's bilateral trade with the EU+2 and Asia as it becomes challenging to cover trade relations with other regions given data limitations. This provides insights for further studies on trade relations between Nigeria (and other developing economies) and other regions as data becomes available both at product and firm level. Also, the study employs mirror data as there are many missing values in the bilateral trade data, especially at the disaggregate level.

5.7 Areas of Further Research

Three agenda for future research are derived from this study. First, the study could not accommodate the political dimension of environmental and sustainability issues due to the huge differing political interests among governments, as well as relevant national and international bodies and agencies. Further research can focus on these issues, especially in environmental and trade policy negotiations at all levels.Second, the study could not consider land in the various trade models, but capital-labour ratio as resource endowment variable. This is because the H-O model does not explicitly provide a role for it. Again, while labour appears to be an important endowment in Nigeria, capital is more critical in the economies of most of her trading partners. Further studies can run different trade models considering the role of the various resource endowment variables, such as capital-labour ratio, fuel export, land among others. Further studies can also consider bilateral trade models between other developing economies and other regions as required data becomes available both at disaggregate levels (product and firm level).

References

Abdallah K. B., Belloumi M. and De Wolf D. 2015. International comparisons of energy and environmental efficiency in the road transport sector. *Energy 93: 2087-2101*

Adewuyi, A. O. and Arawomo, D. F. 2013. The Role of Institutions and Product Differentiation in Imports Surge: Evidence from China-Nigeria Trade Flows, *The Nigerian Journal of Economic and Social Studies (NJESS), 55, 3*

Adewuyi A. O. and Awodumi O. B. 2017. Biomass energy consumption, economic growth and carbon emissions: Fresh evidence from West Africa using a simultaneous equation model. *Energy 119 (2017) 453-471*

Adewuyi A. O. andAwodumi O. B. 2021. Environmental pollution, energy import, and economicgrowth: evidence of sustainable growth in South Africa and Nigeria.*Environmental Science and Pollution Research,* 28(12):14434–14468 https://doi.org/10.1007/s11356-020-11446-z

Adewuyi A. O. and Bankole A. S. 2012. Are there potential Economic Benefits from China-Nigeria Trade Agreements? -*African Journal of Economic Policy,* 19(1): 15-50

Adewuyi, A.O. and Olubiyi, E. A. 2015. Do Governance Institutions Matter for Trade of Sub-Saharan Africa? *African Journal of Economic Policy,* 22 (1), 16-37.

AgroNigeria. 2016. Nigerian Beans Export still banned. Accessed at https://agronigeria.com.ng/nigerian-beans-export-still-banned-eu-official-insists//, on 13th March, 2017

Aigner D. J. and Chu S. F. 1968. On estimating the industry production function. *American Economic Review 58: 826–39.*

Akbostanci E., Tunc G. I. and Turut-Asik S. 2004. Pollution Haven Hypothesis and the Role of Dirty Industries in Turkey's Exports. Economic Research Center, Working Paper in Economics, 0403, March, 2004

Aldanondo-Ochoa A. M, Casasnovas-Oliva V. L. and Arandia-Miura A. 2014. Environmental efficiency and the impact of regulation in dryland organic vine production. *Land Use Policy 36: 275– 284*

Aluko M. A. O., Akinola G. O. and Fatokun S. 2004. Globalization and the Manufacturing Sector: A study of Selected Textile Firms in Nigeria. *Journal of Social Sciences 9(2): 119-130*

Ambec S., Cohen M. A., Elgie S. and Lanoie P. 2011. The Porter Hypothesis at 20: Can Environmental Regulation Enhance Innovation and Competitiveness? Resources for the Future, Discussion Paper 11-01

Anderson J. E. 1979. A Theoretical Foundation for the Gravity Equation. *American Economic Review, 69:106- 116*.

Anderson, J and D. Marcouiller 2000. "Insecurity and the Pattern of Trade: An Empirical Investigation" *Working Paper of Boston College.*

Anderson J. E. and van Wincoop E. 2003. Gravity with Gravitas: A solution to the border puzzle. *American Economic Review63: 881-892.*

Arimura, T., A. Hibiki, and N. Johnstone 2007. An Empirical Study of Environmental R&D: What Encourages Facilities to Be Environmentally-Innovative? in *Corporate Behaviour and Environmental Policy*, edited by N. Johnstone. Cheltenham, UK: Edward Elgar inassociation with OECD.

Armington, P. 1969. A Theory of Demand for Products Distinguished by Place of Production. IMF Staff Papers 16(3): 159-176.

Asiedu E. 2013. Foreign Direct Investment, Natural Resources and Institutions. International Growth Centre, Working Paper, March 2013

Asmild, M., Paradi, C.V., Aggarwall, V., Schaffnit, C., 2004. Combining DEA window analysis with the Malmquist Index approach in a study of the Canadian banking industry. *Journal of Productivity Analysis 21, 67–89*.

Asuero A. G., Sayago A. and Gonzalez. A. G. 2006. The Correlation Coefficient: An Overview. *Critical Reviews in Analytical Chemistry,* 36:41–59

Awolowo O. 2018. Challenges to Export in Nigeria and the Way Forward. Nigerian Export Promotion Council (NEPC), 2018 Lagos Chamber of Commerce and Industry Annual Symposium. https://lagoschamber.ng/wp-content/uploads/2018/08/Export-Challenges-and-Way-Forward-nepc-presentation.pdf, accessed on 12 December, 2018

Azad M. A. S. and Ancev T. 2014. Measuring environmental efficiency of agricultural water use: A Luenberger environmental indicator. *Journal of Environmental Management 145 (2014) 314-320*

Baier, Scott L. & Bergstrand, Jeffrey H., 2007. "Do free trade agreements actually increase members' international trade?," *Journal of International Economics,* 71(1), 72-95

Bankole A. S. 2003a. Costs of Meeting Export Markets' Sanitary and Phytosanitary Standards: Evidence from Nigerian Processed Agricultural and Food Products Export Firms. *African Journal of Economic Policy, 10(1): 33-53*

Bankole A. S. 2003b. An econometrics analysis of firms' compliance costs of sanitary and phytosanitary standards (SPS) in Nigeria's export markets: the case of processed agricultural and food products. *African Journal of Economic Policy, 10(2): 103-136*

Bankole A. S., Olasehinde N. and Raheem A. 2012. ECOWAS Trade Liberalization Scheme (ELTS) and its Impact on Intra-Regional Trade. Journal of West Africa Integration. 1(1), 86-124.

Bergstrand JH 1985. The Gravity Equation in International Trade: Some Microeconomic Foundations and Empirical Evidence. *Review of Economics and Statistics 67: 474-481*.

Berman E. and Bui L.T.M. 2001. Environmental Regulation and Productivity: Evidence from Oil Refineries, *Review of Economics and Statistics* 83(3), 498–510

Bogetoft, P. and Otto L. 2011. *Benchmarking with DEA, SFA and R*, Springer Science

Borchert I. and Yotov Y. V. 2017. Distance, globalization, and international trade. *Economics Letters 153 (2017) 32–38*

Boyd G. A., Molburg J. C. and Prince R. 1996. Alternative methods of marginal abatement cost estimation: nonparametric distance functions. In: Proceedings of the USAEE/IAEE 17th conference; 1996. 86–95.

Brander J. and Krugman P. 1983. A reciprocal dumping model of international trade. *Journal of International Economics*. 15: 313–321.

Brunnermeier, S.B., and M.A. Cohen 2003. Determinants of Environmental Innovation in US Manufacturing Industries, *Journal of Environmental Economics and Management* 45, 278–293.

Burger, M., van Oort, F., and Linders, G. 2009. On the Specification of the Gravity Model of Trade: Zeros, Excess Zeros and Zero-inflated Estimation, *Spatial Economic Analysis, 4 (2), 167-190.*

Busenhart J. 2014. Environmental law and regulation in the European Union. Swiss Re Centre for Global Dialogue

Chang Y., Park H., Jeong J. and Lee J. 2014. Evaluating economic and environmental efficiency of global airlines: A SBM-DEA approach. *Transportation Research Part D 27: 46–50*

Charnes, A., Cooper, W.W., Rhodes, E. 1978. Measuring the Efficiency of Decision Making Units, *European Journal of Operational Research,* 2: 429-444

Chen J., Song M. and Xu L. 2014. Evaluation of environmental efficiency in China using data envelopment analysis. *Ecological Indicators, 52: 577-583*

Chen L and Jia G. 2016. Environmental efficiency analysis of China's regional industry: a data envelopment analysis (DEA) based approach. *Journal of Cleaner Production, 142, Part 2, (20): 846-853*

Chibundu, V. N. 2000. *Nigeria-China foreign relations*, 1960-1999. Ibadan: Spectrum Books.

Chin A. T. H. and Low J. M. W. 2010. Port performance in Asia: Does production efficiency imply environmental efficiency? *Transportation Research Part D 15 (2010) 483–488*

Christmann, P. and Taylor, G. 2001. Globalization and the environment: Determinants of firm self-regulation in China, *Journal of International Business Studies, 32(3): 439-458.*

Cicea C., Marinescu C., Popa I and Dobrin C. 2014. Environmental efficiency of investments in renewable energy: Comparative analysis at macroeconomic level. *Renewable and Sustainable Energy Reviews* 30 (2014) 555–564

Clark T. S. and Linzer D. A. 2015. Should I Use Fixed or Random Effects? Political Science Research and Methods 3: 2, 399–408

Coelli T J, Rao D S P, O'Donnell C J and Battese G E 2005. *An Introduction to Efficiency and Productivity Analysis*. Second Edition, Springer, New York.

Cole M. A. 2004. Trade, the pollution haven hypothesis and the environmental Kuznets curve: examining the linkages. *Ecological Economics 48: 71– 81*

Cole M. A. and Elliot R. J. R. 2003. *Do Environmental Regulations Influence Trade Patterns? Testing Old and New Theories*. Blackwell Publishing Ltd

Consumer Protection Council 2012. Annual Report. Nigeria: CPC Publications.

Copeland, B.R. and Taylor M. S. 1995. "Trade and the Environment: A Partial Synthesis", *American Journal of Agricultural Economics, 77(3): 765-771.*

Copeland, B.R., and Taylor M.S. 1994. North-South Trade and the Environment., *Quarterly Journal of Economics, 109(3): 755-787.*

Copeland, B.R., and Taylor M.S. 2003. *Trade and the Environment: Theory and Evidence*, Princeton University Press, Princeton, NJ.

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

Costa H., Floater G., Hooyberghs H., Verbeke S. and De Ridder K. 2016. Climate change, heat stress and labour productivity: A cost methodology for city economies. Centre for Climate Change Economics and Policy Working Paper No. 278, and Grantham Research Institute on Climate Change and the Environment Working Paper No. 248

Costantini V. and Crespi F. 2008. Environmental regulation and the export dynamics of energy technologies. *Ecological Economics 66: 447 – 460*

Cristea A., Hummels D., Puzzello L. and Avetisyan M. 2013. Trade and the greenhouse gas emissions from international freight transport. *Journal of Environmental Economics and Management 65: 153–173*

Crotty J. and Smith M. 2008. Strategic Responses to Environmental Regulation in the U.K. Automotive Sector: The European Union End-of-Life Vehicle Directive and the Porter Hypothesis, *Journal of Industrial Ecology* 10(4), 95–111.

Deardorff A. V. 2005. Ricardian comparative advantage with intermediate inputs. *North American Journal of Economics and Finance* 16 (2005) 11–34

Deen-Swarray M., Adekunle B. and Odularu G. 2012. Infrastructure Development and Intra-Regional Trade: The Case of ECOWAS. *Journal of West Africa Integration 1(1): 161-186.*

Dios-Palomares R. and Martínez-Paz J. M. 2011. Technical, quality and environmental efficiency of the olive oil industry. *Food Policy 36: 526–534*

Dixit A. and Norman V. 1980. Theory of International Trade: A Dual, General Equilibrium Approach. Cambridge University Press, Cambridge

Dogan E. and Seker F. 2016. The influence of real output, renewable and non-renewable energy, trade and financial development on carbon emissions in the top renewable energy countries. *Renewable and Sustainable Energy Reviews 60: 1074–1085*

Doganay S. M., Sayek S. and Taskın F. 2014. Is environmental efficiency trade inducing or trade hindering? *Economics* (2014), doi: 10.1016/j.eneco.2014.04.004

DPR, 2015. 2015 Oil and Gas Annual Report. Department of Petroleum Resources. Federal Republic of Nigeria. https://dpr.gov.ng/wp-content/uploads/2015/01/2015-Oil-Gas-Industry-Annual-Report.pdf

Du L. and Mao J. 2015. Estimating the environmental efficiency and marginal CO2 abatement cost of coal-fired power plants in China. *Energy Policy 85: 347–356*

Du L., Hanley A. and Zhang N. 2016. Environmental technical efficiency, technology gap and shadow price of coal-fuelled power plants in China: A parametric meta-frontier analysis. *Resource and Energy Economics 43: 14–32*

ECN & FMST. 2014. National Renewable Energy and Energy Efficiency Policy (NREEEP). Energy Commission of Nigeria (ECN) and Federal Ministry of Science and Technology (FMST). Retrieved from www.energy.gov.ng, on 17th April, 2017

ECN and UNDP. 2005. Renewable Energy master Plan (REMP). Energy Commission of Nigeria (ECN) and United Nations Development Programme (UNDP). Retrieved from Available online at: www.spidersolutionsnigeria.com/wp-content/uploads/2014/08/Renewable-Energy-Master-Plan-2005.pdf, on 20th April, 2017

ECN and UNDP. 2012. Renewable Energy master Plan (REMP). Energy Commission of Nigeria (ECN) and United Nations Development Programme (UNDP). Retrieved from www.energy.gov.ng., on 17th April, 2017

EEA. 2014. Resource-efficient green economy and EU policies. European Environmental Agency Report No 2/2014

EEA. 2015. Air quality in Europe — 2015 report. European Environmental Agency, No 5/2015

EEA. 2016. Fluorinated greenhouse gases 2015: Summary of data reported by companies on the production, import and export of fluorinated greenhouse gases in the European Union. European Environmental Agency Report No 33/2016

EIU 2010. *Country Commerce Nigeria*, Economic Intelligent Unit, New York, April. https://www.eiu.com/.../public download, accessed on 17th April, 2017.

El Hanandeh A. and Gharaibeh M. A. 2016. Environmental efficiency of olive oil production by small and micro-scale farmers in northern Jordan: Life cycle assessment. *Agricultural Systems 148: 169–177*

ELRI. 2011. A Synopsis of Laws and Regulations on the Environment in Nigeria. Environmental Law Research Institute, accessed athttp://www.elri-ng.org/newsandrelease2.html, on 18th April, 2017

Embassy of the People's Republic of China in the Federal Republic of Nigeria. 2004. China-Nigeria Relations, accessed at http://www.mondaq.com/Nigeria/x/53804/Energy+Law/Environment+Law+In+Nigeria, on 17th April, 2017

EPA. 2012. Climate change indicators, Environmental Protection Agency, Washington DC.

ERA 2005. Gas Flaring in Nigeria: A Human Rights, Environmental and Economic Monstrosity. The Climate Justice Programeme, Environmental Rights Action. Available at www.eraction.org, accessed on 17th April, 2017

Erdogan A. M. 2014. Bilateral trade and the environment: A general equilibrium model based on new trade theory. *International Review of Economics and Finance 34: 52–71*

Eskeland, G.S. and Harrison, A.E. 2003. Moving To Greener Pastures? Multinationals and The Pollution Haven Hypothesis, *Journal of Development Economics, 70(1): 1-23*.

Esty, D. 2001. Bridging the Trade-Environment Divide. *Journal of Economic Perspectives.* 15(3), 113–130

Etro F. 2015. Endogenous market structures and international trade. *Scandinavian Journal of Economics 117 (3), 918–956.*

Etro F. 2017. The Heckscher–Ohlin model with monopolistic competition and general preferences *Economics Letters 158: 26–29*

Ewertowska A., Galán-Martín A., Guillén-Gosálbez G., Gavaldá J. and Jiménez L. 2016. Assessment of the environmental efficiency of the electricity mix of the top European economies via data envelopment analysis. *Journal of Cleaner Production* (2016), doi: 10.1016/j.jclepro.2015.11.100.

European Commission 2016. Anti-Dumping, Anti-Subsidy, Safeguard: *Statistics Covering the First 10 Months of 2016.*European Commission ***(October 2016)***

European Commission 2017a. Commission welcomes agreement on new anti-dumping methodology. European Commission Press release, Strasbourg, 3 October 2017, accessed athttp://europa.eu/rapid/press-release_IP-17-3668_en.htm, on 7th March, 2018

European Commission 2017b. The EU is changing its anti-dumping and anti-subsidy legislation to address state induced market distortions. European Commission Press release, Brussels 4 October 2017, Accessed at http://europa.eu/rapid/press-release_MEMO-17-3703_en.htm, 7th March, 2018

Doherty R. M., Heal M. R. and O'Connor F. M. 2017. Climate change impacts on human health over Europe through its effect on air quality. Doherty et al. *Environmental Health,* 16(Suppl 1:118): 33-44

Faga H. P. and Uchechukwu U. 2019. Oil Exploration, Environmental Degradation, and Future Generations in the Niger Delta: Options for Enforcement of Intergenerational Rights and Sustainable Development Through Legal and Judicial Activism. *Journal of Environmental Law and Litigation,* 34: 185-218

Fakinle, B. S., Sonibare, J. A., Akeredolu, F. A., Okedere, O. B., &Jimoda, L. A. 2013. Toxicity potential of particulate in the airshed of haulage vehicle park. *Global NEST Journal, 15, 466–473.*

Färe R. C. and Grosskopf S. 1983. Measuring output efficiency. *European Journal of Operational Research, 13(2), 173-179*

Färe R., Grosskopf S., Lovell C. A., Noh D. and Weber W. L. 2005. Characteristics of a polluting technology: theory and practice. *Journal of Econometrics 126: 469–92.*

Fare, R., Grosskopf, S., and Hernandez-Sancho, F. 2004. Environmental performance: An index number approach. Resource and Energy Economics, 26, 343–352.

Färe R., Grosskopf S., Lovell C.A. and Yaisawarng S. 1993. Derivation of shadow prices for undesirable outputs: a distance function approach. *Review of Economic Statistics.75: 374–80.*

Färe, R., Grosskopf, S., Zaim, O., 2003. An Environmental Kuznets Curve for the OECD countries. In: Färe, R., Grosskopf, S. (Eds.), New Directions: Efficiency and Productivity. Kluwer Academic Publishers, pp. 79–90.

Federal Ministry of Environment 2016.National Policy on the Environment (Revised 2016). Federal Ministry of Environment, Nigeria, Policy Document

Feenstra, R.C 2004. Advanced International Trade: Theory and Evidence, Princeton, Princeton University Press.

Frankel, J. 1997. "Regional Trading Blocs in the World Economic System", Institute for International Economics, Washington D.C.

George Etomi& Partners. 2014. *Environmental Legislation Changes in Nigeria: What Impact on Foreign Investment?* Sampson Ebomhe Esq: George Etomi& Partners: accessed at*http://geplaw.com/wp-content/uploads/2014/11/Environmental-Legislation-Changes-in-Nigeria, 1*7th April, 2017

Goto M., Otsuka A. and Sueyoshi T. 2014. DEA (Data Envelopment Analysis) assessment of operational and environmental efficiencies on Japanese regional industries. *Energy: 66: 535–549*

Gozgor G. and Can M. 2016. Export Product Diversification and the Environmental Kuznets Curve: Evidence from Turkey. *Environmental Science Pollution Resources 23: 21594–21603*

Gray K. R. 2002. Foreign Direct Investment and Environmental Impacts – Is the Debate Over? *RECIEL 11 (3): 306-313*

Gray, W.B., and R.J. Shadbegian 2003. Plant Vintage, Technology, and Environmental Regulation, *Journal of Environmental Economics and Management* 46, 384–402.

Gujarati D. N. 2004. Basic Econometrics. Fourth Edition, The McGraw−Hill Companies

Hailu A. and Veeman T. S. 2000. Environmentally sensitive productivity analysis of the Canadian pulp and paper industry, 1959–1994: an input distance function approach. *Journal of Environmental Economics and Management. 40: 251–74.*

Halkos G. E. and Tzeremes N. G. 2009. Exploring the existence of Kuznets curve in countries' environmental efficiency using DEA window analysis. *Ecological Economics 68: 2168–2176*

Halkos G. E. and Tzeremes N. G. 2013a. Economic growth and environmental efficiency: Evidence from US regions. *Economics Letters 120: 48–52*

Halkos G. E. and Tzeremes N. G. 2013b. A conditional directional distance function approach for measuring regional environmental efficiency: Evidence from UK regions. *European Journal of Operational Research 227: 182–189*

Hamilton C. B. and Winters L. A. 1992. "Trade with Eastern Europe." *Economic Policy 17, 78-116.*

Harris M. N., Konya L and Matyas L. 2002. *Modelling the Impact of Environmental Regulations on Bilateral Trade Flows: OECD, 1990–1996*. Blackwell Publishers Ltd 2002

Helpman, E., 1999. The structure of foreign trade. *Journal of Economic Perspectives 13, 121–144.*

Helpman E, Krugman P 1985. *Market structure and foreign trade: increasing returns, imperfect competition and the international economy*. MIT Press, Cambridge

Hering L and Poncet S. 2014. Environmental policy and exports: Evidence from Chinese cities. *Journal of Environmental Economics and Management 68: 296–318*

Hong, P. 1999. "Import Elasticities Revisited," Discussion Paper, 10, *Department of Economic and Social Affairs*, United Nations, http://www.un.org/esa/paper.htm.

Honma S. 2015. Does international trade improve environmental efficiency? An application of a super slacks-based measure of efficiency. *Journal of Economic Structures: 4(13): 1-12*

Hussein A. and Kachwamba M. 2011. Low Quality products in Developing Countries' Markets: Is it one of Globalization Challenges? *International Review of Social Sciences and Humanities; 26-36.*

Ijaiya and H. Joseph O. T. 2014.Rethinking Environmental LawEnforcement in Nigeria. *Beijing Law Review, 5,* 306-321.

IEA. 2009. CO2 Emissions from Fuel Combustion 2009 - Highlights. (Organization for Economic Cooperation and Development, Paris, 2006), International Energy Agency.

Isola W. A. and Mesagan E. P. 2015. Impact of Oil Production on Human Condition in Nigeria. MPRA Paper No. 67784, posted 13. November 2015 01:27 UTC, https://mpra.ub.uni-muenchen.de/67784/

Iwayemi, A., Diji, C., Awotide, B., Adenikinju, A. and Obute, P. 2015. Towards Sustainable Universal Electricity Access in Nigeria. CPEEL. (2014). Retrieved August 6, 2015, from Available online at: www.cpeel.ui.edu.ng/sites/default/files/monograph-2.pdf.

Kohn R. E. 2000. The effect of environmental taxes on the volume of international trade. *Ecological Economics 34: 77–87*

Kounetas K. 2015. Heterogeneous technologies, strategic groups and environmental efficiency technology gaps for European countries. *Energy Policy, 83, 277-287*

Krugman P.R. and Obstfeld M. 2005. International Economics: Theory and Policy. Seventh Edition, Addison-Wesley

Kumbhakar S. C. and Lovell C. A. 2000. *Stochastic frontier analysis.* Cambridge, UK: Cambridge University Press; 2000

Kuo H., Chen and Tsou K. 2014. Analysis of Farming Environmental Efficiency Using a DEA Model with Undesirable Outputs *APCBEE Procedia 10: 154 – 158*

Lahiri S, and Ono Y. 1995. The role of free entry in an oligopolistic Heckscher-Ohlin Model. *International Economic Review. 36 (3), 609–624.*

Landis F., Schenker O., Reaños M. A. T., and Zitzelsberger S. 2012. An Overview on Current Climate Policies in the European Union and its Member States. Sevent Framework Programme, FP7-ENV-2012 GA No.308481

Lannelongue G., Gonzalez-Benito J., Quiroz I. 2017. Environmental management and labour productivity: The moderating role of capital intensity. *Journal of Environmental Management* 190 (2017) 158-169

Lanoie, P., M. Patry, and R. Lajeunesse 2008. Environmental Regulation and Productivity: New Findings on the Porter Hypothesis, *Journal of Productivity Analysis* 30, 121–128.

Lee T., Yeo G. and Thai V. V. 2014. Environmental efficiency analysis of port cities: Slacks-based measure data envelopment analysis approach. *Transport Policy 33: 82–88*

Li H., Fang K., Yang W., Wang D. and Hong X. 2013b. Regional environmental efficiency evaluation in China: Analysis based on the Super-SBM model with undesirable outputs. *Mathematical and Computer Modelling 58: 1018–1031*

Li M. and Wang Q. 2014. International environmental efficiency differences and their determinants. *Energy 78: 411-420*

Li X., Yang J. and Liu X. 2013a. Analysis of Beijing's environmental efficiency and related factors using a DEA model that considers undesirable outputs *Mathematical and Computer Modelling 58: 956–960*

Li Y., Zhang Q., Wang L. and Liang L. 2020. Regional environmental efficiency in China: An empirical analysisbased on entropy weight method and non-parametric models. *Journal of Cleaner Production,*276: 124147

Li Z., Xu N. and Yuan J. 2015. New evidence on trade-environment linkage via air visibility. *Economics Letters 128 (2015) 72–74*

Lin E. Y., Chen P. and Chen C. 2013. Measuring the environmental efficiency of countries: A directional distance function metafrontier approach. *Journal of Environmental Management 119: 134-142*

Linders, G.J.M, and De Groot, H.L.F. 2007. Estimation of the Gravity Equation in the Presence of Zero Flows, Tinbergen Institute of Economic Research Discussion Paper (TI 2006-072/3), Amsterdam

Liu X., Wang C. and Wei Y. 2009.Do local manufacturing firms benefit fromtransactional linkages with multinationalenterprises in China?*Journal of International Business Studies,* 40, 1113–1130

Makinde O. and Adeyoke T. 2007. Nigeria: Environment Law in Nigeria. Mondaq, 20 November 2007, accessed at http://www.mondaq.com/Nigeria/x/53804/Energy+Law/Environment+Law+In+Nigeria, on 17th April, 2017

Marklund P. O. and Samakovlis E. 2007. What is driving the EU burden-sharing agreement: efficiency orequity? *Journal of Environmental Management.* 85: 317–329.

Markusen J. R., Melvin J. R., Kaempfer W. H. and Maskus K. E. 1995. *International Trade: Theory and Evidence.* Mc Graw-Hill, Inc.

Matsushita K. and Yamane F. 2012. Pollution from the electric power sector in Japan and efficient pollution reduction. *Energy Economics.* 34: 1124–1130.

Mehra N. and Yaruingam A.S. 2015. India-Nigeria Relations (From Historical Friends to Strategic Partners). *International Journal of Political Science and Development 3(5), 232-239*

Michieka N. M., Fletcher J. and Burnett W. 2013. An empirical analysis of the role of China's exports on CO2 emissions. *Applied Energy 104 (2013) 258–267*

Mulatu A., Florax R. J. G. M. and Withagen C. A. 2004. Environmental Regulation and International Trade. Tinbergen Institute Discussion Paper. 2004-020/3

Narayan P. K. and Narayan S. 2010. Carbon dioxide emission and economic growth: panel data evidence from developing countries. *Energy Policy 38: (1): 661–6.*

NBS. 2015. Foreign Trade Statistics, Second Quarter, 2015. National Bureau of Statistics. www.nigeriastat.gov.ng

NEPC. 2014. Implementation of AGOA in Nigeria. Nigerian Export promotion Council in Nigeria, www.nepc.gov.ng/images/AGOA.

NNPC. 2005. Annual Statistical Bulletin. Nigerian National Petroleum Corporation. www.nnpcgroup.com,accessed on 19th April, 2017

NNPC. 2010. Annual Statistical Bulletin-First Edition. Nigerian National Petroleum Corporation. www.nnpcgroup.com

NNPC. 2015. Annual Statistical Bulletin-First Edition. Nigerian National Petroleum Corporation. www.nnpcgroup.com

NOTN. 2018. Nigeria Signs Legal Agreement to Fight Dumping. Nigerian Office for Trade Negotiation, Press release accessed at http://www.notn.gov.ng/post_action/51,on 10th December, 2018

Ojuri, O. O., Taiwo, O. A., &Oluwatuyi, O. E. 2016. Heavy metal migration along a rural highway route: Ilesha-Akure roadside soil, Southwestern Nigeria. *Global NEST Journal, 18, 742–760*

Okorie A. and Humphrey A. 2016. Standards Organization of Nigeria and Funding Challenges to Quality Control. *Mediterranean Journal of Social Sciences. 7, (5): 67-74*

Oladimeji, T. E., Sonibare, J. A., and Odunfa, K.m., Oresegun, O.R. 2015. Environmental impact analysis of emission from petroleum refineries in Nigeria. *Energy and Environment Research, 5, 33–41.*

Owoeye, J. 1986. Nigeria and China. In Olusanya G.O & Akindele R.A. (eds.) *Nigeria's external relations: The first twenty-five years*. Ibadan: University Press.

Ozcan,B. 2013.Thenexusbetweencarbonemissions,energyconsumptionandeconomic growth in MiddleEast countries: a panel data analysis. *EnergyPolicy2013; 62:1138–47.*

Palmer, K., W. E. Oates, and P.R. Portney 1995. Tightening Environmental Standards: The Benefit-Cost or the No-Cost Paradigm? *Journal of Economic Perspectives* 9(4), 119–132.

Piperopoulos P., Wu J. and Wang C. 2017. Outward FDI, location choices and innovation performance of emerging market enterprises. *Research Policy (2017), http://dx.doi.org/10.1016/j.respol.2017.11.001*

Pittman R. W. 1981. Issues in pollution control: interplant cost differences and economics of scale. *Land Economics; 57: 1–17*

Policy Departments, European Parliament 2015. The United States Environmental Policy: In-depth Analysis of the ENVI Committee. http://www.europarl.europa.eu/studies

Popp, D. 2003. Pollution Control Innovations and the Clean Air Act of 1990, *Journal of Policy Analysis and Management* 22(4), 641–660.

Porter M. E. 1991. America’s Green Strategy. *Scientific American. 264 (4): 96*

Porter M. E. and van der Linde C. 1995. Towards a New Conception of the environment Competitiveness Relationship. *Journal of Economic Perspectives 9(4): 97-118*

Rubashkina Y., Galeotti M. and Verdolini E. 2015. Environmental regulation and competitiveness: Empirical evidence on the Porter Hypothesis from European manufacturing sectors. *Energy Policy 83: 288–300*

Samuelson P.A. 1949. International factor-price equalization once again. *Economic Journal 9, 181–197*

Santos S. J. and Tenreyro S. 2006. "The Log of Gravity", *the Review of Economics and Statistics* 88(4): 641-58.

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

Shao Y. and Wang S. 2016. Productivity growth and environmental efficiency of the nonferrous metals industry: an empirical study of China. *Journal of Cleaner Production* (2016), doi:10.1016/j.jclepro.2016.03.041.

Simar L. and Wilson P.W. 2000. A general methodology for bootstrapping in non-parametric frontier models. *Journal of Applied Statistics. 27: 779–802.*

Song M. and Zheng W. 2015. Computational analysis of thermoelectric enterprises' environmental efficiency and Bayesian estimation of influence factors. *The Social Science Journal, 53(1): 88-99*

Song M. and Zhou Y. 2015. Quantitative Analysis of Foreign Trade and Environmental Efficiency in China. *Emerging Markets Finance and Trade, DOI:10.1080/1540496X.2015.1011559*

Song M., Peng J., Wang J. and Dong L. 2016. Better resource management: An improved resource and environmental efficiency evaluation approach that considers undesirable outputs. *Resources, Conservation and Recycling, In Press, Corrected Proof, http://dx.doi.org/10.1016/j.resconrec.2016.08.015*

Song M., Song Y., Yu H. and Wang Z. 2013. Calculation of China's environmental efficiency and relevant hierarchical cluster analysis from the perspective of regional differences. *Mathematical and Computer Modelling 58 (2013) 1084–1094*

Song M., Zhang G., Zeng W., Liu J. and Fang K. 2015a. Railway transportation and environmental efficiency in China. *Transportation Research Part D: Transport and Environment, 48: 488-498*

Song M., Zheng W. and Wang Z. 2015b. Environmental efficiency and energy consumption of highway transportation systems in China. *International Journal of Production Economics, 181, Part B, 441-449*

Song T., Zheng, T. and Tong L. 2008. An empirical test of the Environmental Kuznets Curve in China: a panel cointegration approach. *China Economic Review: 19(3): 381–92.*

Sonibare, J. A. 2010. Air pollution implications of Nigeria's present strategy on improved electricity generation. *Energy Policy, 38, 5783–5789. https://doi.org/10.1016/j.enpol.2010.05.029*

Sonibare, J. A., Akeredolu, F. A., Obanijesu, E. O. O., & Adebiyi, F. M. 2007. Contribution of volatile organic compound to Nigeria's airshed by petroleum refineries. *Petroleum Science and Technology, 25, 503–516. https://doi.org/10.1080/10916460500295397*

Sun H, Kporsu A. K., Taghizadeh-Hesary F., Edziah B. K. 2020. Estimatingenvironmental efficiency and convergence: 1980 to 2016, *Energy* (2020), doi: https://doi.org/10.1016/j.energy.2020.118224.

Taghizadeh-Hesary F. and Taghizadeh-Hesary F. 2020. The Impacts of Air Pollution on Health and Economy in Southeast Asia Energies, 13(1812): 1-15

Taskin F and Zaim O. 2001. The role of international trade on environmental efficiency: a DEA approach. *Economic Modelling 18: 1-17*

Tateishi H. R., Bragagnolo C. and de Faria R. N. 2020. Economic and environmental efficiencies of greenhouse gases' emissionsunder institutional influence. *Technological Forecasting & Social Change,*161: 120321

Taylor M. S. 2005. Unbundling the Pollution Haven Hypothesis. University of Calgary, Department of Economics. Discussion Paper 2005-15. http://www.econ.ucalgary.ca/research/research.htm, on 17th April, 2017

The Senate, Federal Republic of Nigeria (National Assembly). 2016. Report of the Joint Committee on Health, and Agriculture and Rural Development Report on the Ban of Nigerian Agricultural Export Products by the EU (February, 2016).

Tone K. 2001. A Slack-Based Measure of Efficiency in DEA, *European Journal of Operational Research 130 (2001) 498–509*

Turkson F. E. 2011. Logistics and Bilateral Exports in Developing Countries: A Multiplicative Form Estimation of the Logistics Augmented Gravity Equation, CREDIT Research Paper no 11/06. Centre for Research in Economic Development and International Trade, University of Nottingham

Turner J. 1994. Measuring the cost of pollution abatement in the electric utility industry: a production function approach. PhD dissertation. Chapel Hill: University of North Carolina; 1994.

U. S. Congress 2000. National Environmental Policy Act of 1969. Q:\COMP\ENMISC\NEPA69

UNDP. 2016. Climate Change and Labour: Impacts of Heat in the Workplace. United Nations Development Programme, https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/documents/genericdocument/wcms_476051.pdf

United Nations (2020).World Economic Situation and Prospects 2020. United Nations, New York. https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/WESP2020_Annex.pdf

Valadkhani A., Roshdi I. and Smyth R. 2015. How successful was Kyoto? A multiplicative environmental DEA approach to measure efficiency changes in the world's major polluters. *Energy Economics (2016)*, doi:10.1016/j.eneco.2015.12.018

van Beers C. and van den Bergh J. C. J. M. 2000. The Impact of Environmental Policy on Foreign Trade. Tinbergen Institute Discussion Paper. 2000-069/3

Varian H. R. 1992. *Microeconomic Analysis*. Third Edition. W. W. Norton & Company, Inc., New York

Vanek J. 1959. The Natural Resource Content of Foreign Trade, 1870-1955, and the Relative Abundance of Natural Resources in the United States Author(s): *The Review of Economics and Statistics, Vol. 41, No. 2, Part 1, pp. 146-153*

Vlontzos G., Niavis S. and Manos B. 2014. A DEA approach for estimating the agricultural energy and environmental efficiency of EU countries. *Renewable and Sustainable Energy Reviews 40: 91–96*

Wang Q., Zhao Z., Shen N. and Liu T. 2014. Have Chinese cities achieved the win–win between environmental protection and economic development? From the perspective of environmental efficiency. *Ecological Indicators, Volume 51, Pages 151-158*

Wang K., Lu B. and Wei Y. 2013. China's regional energy and environmental efficiency: A Range-Adjusted Measure based analysis. *Applied Energy 112: 1403–1415*

WBCSD 2000. Eco-Efficiency -creating more value with less impact 2000. The World Business Council for Sustainable Development (WBCSD). www.wbcsd.org, accessed on 18th January 2017

Wendling, Z. A., Emerson, J. W., de Sherbinin, A., Esty, D. C., et al. (2020). 2020 Environmental Performance Index. New Haven, CT: Yale Center for Environmental Law & Policy. epi.yale.edu

WHO. 2012. Global Health Observatory, data repository, World Health Organization, 2012 accessed at http://www.who.int/gho/en/,on 17th April, 2017

WHO. 2014. Burden of disease from Ambient Air Pollution for 2012 — Summary of results, World Health Organization (http://www.who.int/phe/health_topics/ outdoorair/databases/AAP_BoD_results_March2014. pdf) accessed 4 September 2015.

WHO 2015. Climate and Health Country Profile – 2015: Nigeria. World Health Organization, Switzerland, accessed on 7th March, 2018 at http://apps.who.int/iris/bitstream/10665/208865/1/WHO_FWC_PHE_EPE_15.11_eng.pdf

Wikipedia 2018.Paris Agreement. Accessed athttps://en.wikipedia.org/wiki/ParisAgreement, 7th March, 2018

Wikipedia 2018.Kyoto Protocol. Accessed athttps://en.wikipedia.org/wiki/Kyoto_Protocol, 7th March, 2018

World Bank. 2013. Low Carbon Development Directions in Development: Opportunities for Nigeria; in Direction in Development: Countries and Regions. The World Bank, Washington D. C. http://dx.doi.org/10.1596/978-0-8213-9925-5, on 17th April, 2017

World Bank. 2017. World Development indicators. World Bank Database

WTO. 2011. Trade Policy Review Report by Nigeria. Trade Policy Review Body, World Trade Organization. WT/TPR/G/247

WTO. 2013. China files dispute against the United States on anti-dumping measures involving Chinese products. World Trade Organization 2013 News items, accessed at https://www.wto.org/english/news_e/news13_e/ds471rfc_03dec13_e.htm, on 17th April, 2017

WTO. 2014a. Canada files dispute against China over anti-dumping measures on cellulose pulp, World Trade Organization 2014 News items, accessed at https://www.wto.org/english/news_e/news14_e/ds483rfc_15oct14_e.htm,on 17th April, 2017

WTO 2014b. Sanitary and Phytosanitary Measures. World Trade Organization E-Learning, February 2014, accessed at https://ecampus.wto.org/admin/files/Course_619/CourseContents/SPS-R4-E-Print.pdf, on 17th April, 2017

WTO. 2014c. The WTO Agreements Series Technical Barriers to Trade. World Trade Organization. World Trade Organization (WTO) Agreements Series, accessed at https://www.wto.org/english/res_e/publications_e/tbttotrade_e.pdf, on 21st April, 2017

WTO. 2015. Appellate Body issues reports on EU, Japan complaints against Chinese steel duties. World Trade Organization 2015 News items, accessed at https://www.wto.org/english/news_e/news15_e/460abr_e.htm, on 17th April, 2017

WTO. 2017. Members Exchange Views, Concerns on Recent Anti-Dumping Actions. World Trade Organization News items, 25 October 2017, accessed at Https://www.wto.Org/English/News_E/News17_E/Anti_25oct17_E.Htm,on 7th March, 2018

Woo C., Chung Y., Chun D., Seo H. and Hong S. 2015. The static and dynamic environmental efficiency of renewable energy: A Malmquist index analysis of OECD countries. *Renewable and Sustainable Energy Reviews 47: 367–376*

Wu J., An Q., Yao X. and Wang B. 2014. Environmental efficiency evaluation of industry in China based on a new fixed sum undesirable output data envelopment analysis. *Journal of Cleaner Production, 74(1): 96-104*

Wu J., Zhu Q., Chu J., Liu H. and Liang L. 2015. Measuring energy and environmental efficiency of transportation systems in China based on a parallel DEA approach. *Transportation Research Part D: Transport and Environment, 48: 460-472*

Xie X. M., Zang Z. P. and Qi G. Y. 2015. Assessing the Environmental Management Efficiency of Manufacturing Sectors: Evidence from Emerging Economies. *Journal of Cleaner Production (2015), doi: 10.1016/j.jclepro.2015.08.006.*

Xu X. 2000. International Trade and Environmental Regulation: Time Series Evidence and Cross Section Test. *Environmental and Resource Economics 17: 233–257.*

Yang L. and Zhang X. 2016. Assessing regional eco-efficiency from the perspective of resource, environmental and economic performance in China: A bootstrapping approach in global data envelopment analysis. *Journal of Cleaner Production, http://dx.doi.org/10.1016/j.jclepro.2016.07.166*

Yang X., Feng K., Su B., Zhang W. and Huang S. 2019. Environmental efficiency and equality embodied in China'sinter-regional trade. *Science of the Total Environment,*672: 150–161

Yang L., Ouyang H., Fang K., Ye L. and Zhang J. 2014. Evaluation of regional environmental efficiencies in China based on super-efficiency-DEA. *http://dx.doi.org/10.1016/j.ecolind.2014.08.040*

Yörük B. K. and Zaim O. 2006. The Kuznets curve and the effect of international regulations on environmental efficiency. *Economics Bulletin, 17(1): 1−7*

Young L.1991. Hechscher-Ohlin Trade Theory with Variable Returns to Scale. *Journal of International Economics 3 1: 183- 190*

Yusuff A. Q. and Ajayi S. O., Akanbi O. A. and Amusa S. O. 2020. Econometric Analysis of Consumer Price Index on Some MajorEconomic Indicators. *International Journal of Applied Science and Mathematical Theory,* 6(3): 19-25

Zaim, O., 2004. Measuring environmental performance of state manufacturing through changes in pollution intensities: a DEA framework. *Ecological Economics 48, 37–47.*

Zaim, O., Färe, R., Grosskopf, S., 2001. An economic approach to achievement and improvement indexes. Social Indicators Research 56, 91–118.

Zhang J. 2015. Carbon emission, energy consumption and intermediate goods trade: A regional study of East Asia. *Energy Policy 86: 118–122*

Zhang J., Zeng W. and Shi H. 2016. Regional environmental efficiency in China: Analysis based on aregional slack-based measure with environmental undesirable outputs. *Ecological Indicators 71: 218–228*

Zhang N. and Choi Y. 2014. A note on the evolution of directional distance function and its development in energy and environmental studies 1997–2013. *Renewable and Sustainable Energy Reviews, 33: 50-59*

Zhang J. and Kristensen G. 1995. A Gravity Model with Variable Coefficients: The EEC Trade with Third Countries. *Geographical Analysis, 27 (4),* Ohio State University Press

Zhou P., Ang B. W. and Han J. Y. 2010. Total factor carbon emission performance: a Malmquist index analysis. *Energy Economics. 32: 194–201.*

Zhou P., Ang B. W. and Poh K. L. 2008. A survey of data envelopment analysis in energy and environmental studies. *European Journal of Operational Research. 189: 1–18*

Zhou Y., Xing X., Fang K. Liang D. and Xu C. 2013. Environmental efficiency analysis of power industry in China based on an entropy SBM model. *Energy Policy 57: 68–75*

Zhou, P., Zhou, X., Fan, L.W. 2014. On estimating shadow prices of undesirable outputs with efficiency models: a literature review. *Applied Energy 130, 799–806.*

Appendix A

Table A1: CO2 Emissions in Nigeria and Top Asia and the EU+2

Variable	1996	2001	2006	2011	2012	2013	2014
CO2 emissions in Nigeria (kt)	404,21.34	83,350.91	98,513.96	88,026.34	86,594	84,862.74	83,298.6
Combined CO2 emissions of top EU+2 partners (kt)	2,830,367	2,891,895	2,915,470	2,534,055	2,523,798	2,490,260	2,561,688
Combined CO2 emissions of top Asia partners (kt)	6,412,465	6,726,206	10,034,856	13,497,600	11,862,110	12,117,904	12,337,955

Table A2: Carbon Intensity of Nigerian Exports to Asia and the EU+2

Variable	1996	2001	2006	2011	2012	2013	2014
Carbon intensity of export to Asia	1.79	1.35	1.35	0.99	0.60	1.01	0.58
Carbon intensity of export to EU+2	0.37	0.92	1.99	0.48	0.36	0.43	0.36

Table A3: Carbon Intensity of Nigerian Imports from Asia and the EU+2

Variable	1996	2001	2006	2011	2012	2013	2014
Carbon intensity of Import from the EU+2	109.45	69.67	50.73	37.21	65.67	42.67	40.08
Carbon intensity of Import from Asia	765.56	294.81	193.99	153.76	160.00	140.20	120.80

Source: Compiled by Author

Table A4a: List of Selected Nigeria's Top Trading Partners in the EU+2

1	France
2	Germany
3	Italy
4	Netherlands
5	Norway
6	Portugal
7	Spain
8	Sweden
9	Switzerland
10	United Kingdom

Source: Compiled by Author

Table A4b: List of Selected Nigeria's Top Trading Partners in Asia

1	China
2	Hong Kong
3	India
4	Indonesia
5	Japan
6	Korea, Rep.
7	Singapore

Source: Compiled by Author

Appendix B

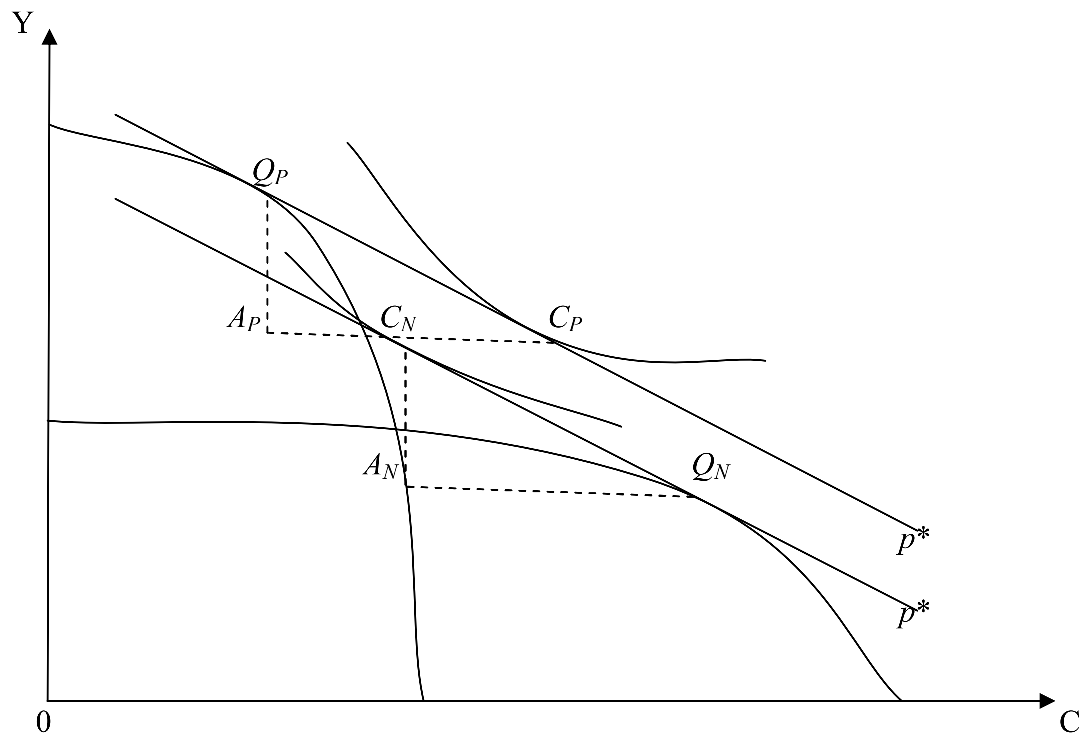

Figure B1: Comparative advantage and trade in the H-O model
Source: Markusen et al, 1995

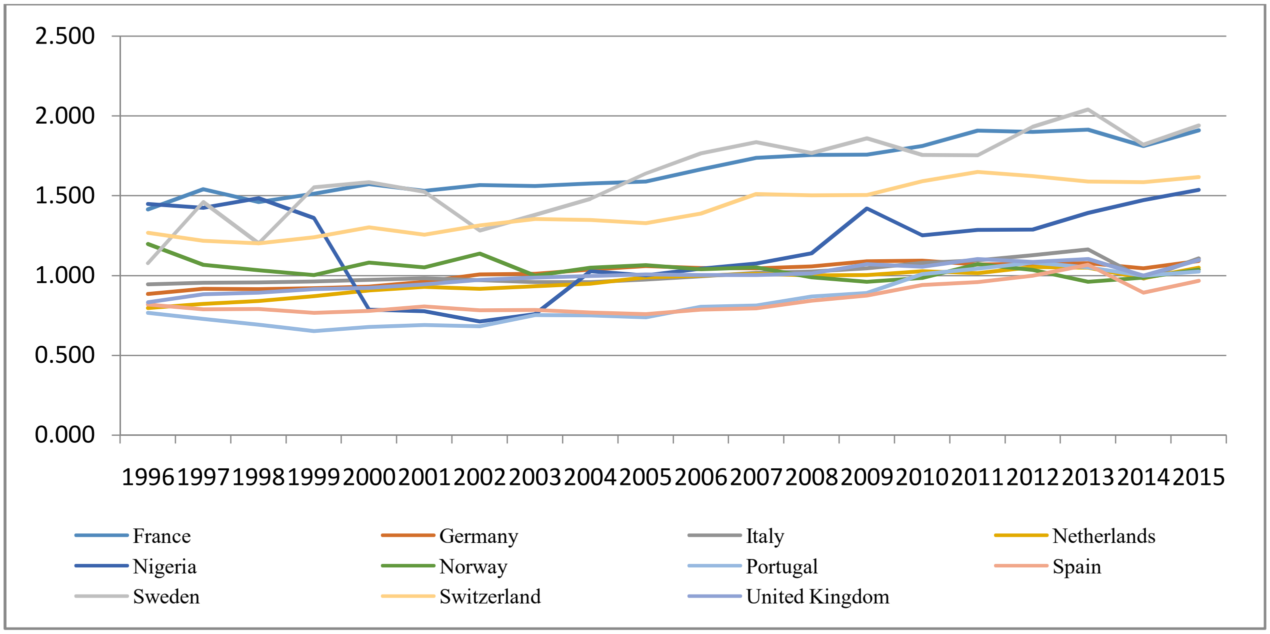

Figure B2. Environmental Efficiency in Nigeria and the EU+2

Source: Author, Obtained from DEA

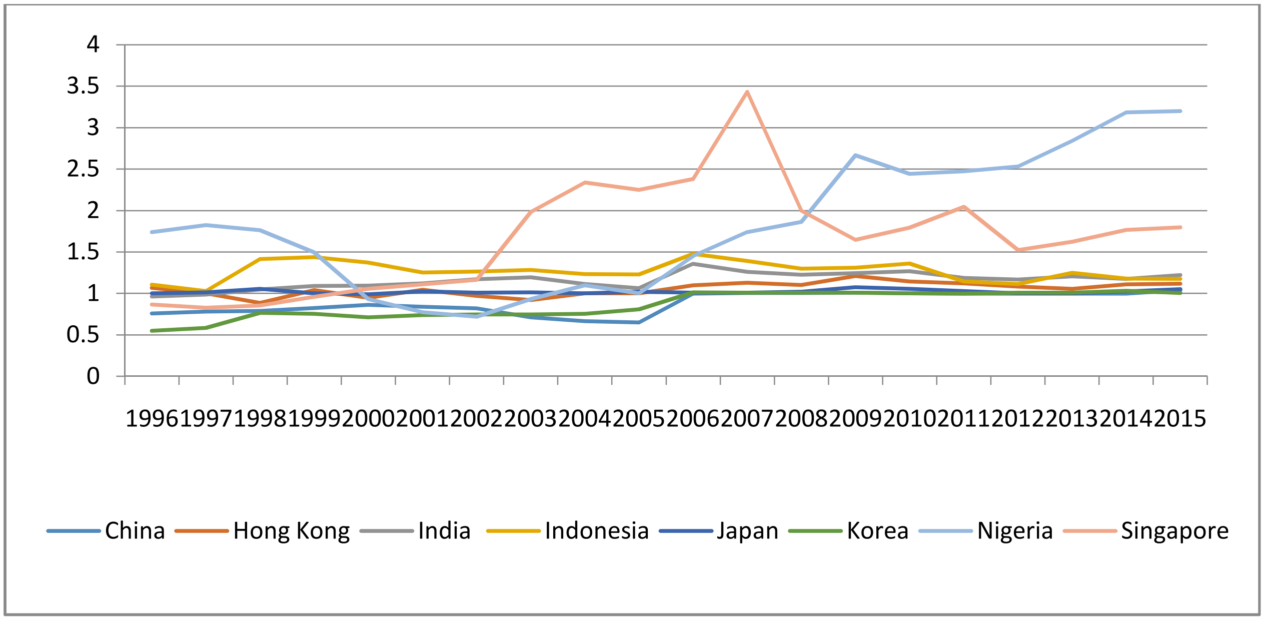

Figure B3. Environmental Efficiency in Nigeria and Asia
Source: Author, Obtained from DEA