Foreign Direct Investment and Sustainable Development in Sub-Saharan Africa

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Declaration

In accordance with the Regulations for Higher Degrees by Research, I hereby declare that the whole thesis now submitted for the candidature of Doctor of Philosophy is a result of my own research and independent work except where reference is made to published literature. I also hereby certify that the work embodied in this thesis has not already been submitted in any substance for any degree and is not being concurrently submitted in candidature for any degree from any other institute of higher learning. I am responsible for any errors and omissions present in the thesis.

Candidate: _____

Marian Ojoshimite Omojimite

Abstract

The aim of this study is to empirically examine the determinants of FDI and environmental sustainability in sub-Saharan Africa over the period 1985-2012. This thesis provides a novel framework to examine determinants of FDI and their relationship to sustainable development, particularly in the context where most sub-Saharan African countries are characterised by relatively less stringent environmental regulations and have also adopted substantial structural reforms, mainly driven by liberalisation and private-sector participation. The study begins with the empirical application of the theoretical framework of the modified knowledge-capital (KC) model of multinational enterprises (MNEs) to determine the motives for FDI in sub-Saharan Africa. Using bilateral panel dataset for 30 Organisation for Economic Cooperation and Development (OECD) parent countries and 28 sub-Saharan African host countries, the results indicate that both horizontal and vertical investments are important to sub-Saharan Africa's economy. Furthermore, MNEs are increasingly mobile, searching sub-Saharan Africa for markets, lower costs, raw materials and agglomeration economies. The findings reveal that relative environmental regulatory stringency difference between the parent and host country is a positive and significant determinant of inward FDI, providing evidence of a pollution haven in sub-Saharan Africa.

In addition, using the aggregate variable approach, the study provides an empirical model for examining FDI patterns in 13 sub-Saharan African countries. We construct the new dataset on structural reforms and environmental regulatory stringency based on the energy use approach. The study shows that inward FDI to the region is determined by the host country's level of environmental regulation. The findings indicate that MNEs exploits favourable economic conditions, growth prospect, governance and institutional quality, return on investment, human capital, infrastructure, natural resources and agglomeration economies. Further, trade liberalisation can help promote FDI, however, financial liberalisation such as financial sector development and bank efficiency as well as privatisation of state-owned enterprises has no compelling effect on productive FDI to the region. The results also suggest that more stringent environmental regulation in host countries deter inward productive FDI. We confirm the presence of a pollution haven in sub-Saharan Africa.

Finally, the role of FDI for sustainable development is empirically examined. Using the extended Stochastic Impact by Regression on Population, Affluence and Technology

(STIRPAT) framework, this study conducts a comparative analysis for Nigeria and South Africa during the period of review. We examine the short-run and long-run dynamics between CO_2 emissions and its determinants. Urbanisation contributes to CO_2 emissions reduction in South Africa, while population growth does not increase CO_2 emissions in both countries. The findings confirm that economic growth and energy consumption are key determinants of CO_2 emissions in both countries. While South Africa has maintained a significant reduction in energy intensity and a lesser impact of economic growth on the environment, Nigeria is different. We find no evidence in support of an environmental Kuznets curve (EKC). Moreover, FDI has a negative effect on CO_2 emissions in Nigeria. This supports the pollution halo hypothesis, which posits that FDI is conducive to the transfer and diffusion of 'clean' (energy) technology. The results also suggest that strengthening governance and democratic institutions could improve environmental sustainability.

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Introduction

In contemporary society, foreign direct investment (FDI) plays a vital role in economic development as well as for sustainable development, one of the major goals of the world today, thus has continued to receive attention among researchers and policymakers. In this regard, many African countries are taking steps to improve their investment conditions in order to attract FDI. In recent years, the dismal performance of inward FDI in the continent is troubling. According to the 2014 World Investment Report of the United Nations Conference on Trade and Development (UNCTAD, 2014), substantial FDI is required for developing countries to achieve sustainable development which aims to address social, economic and environmental challenges. However, there is a concern that rapid economic development driven by FDI may also have negative impacts on the environment. This study aims to answer the following research questions:

1. What are the key determinants of sub-Saharan Africa's inward FDI?
2. Do environmental regulatory stringency and structural reforms influence the pattern of inward FDI in sub-Saharan African countries?
3. What are the major drivers of environmental sustainability measured by carbon dioxide (CO_2) emissions in sub-Saharan African countries and to what extent are these factors related to CO_2 emissions in the long-run?
4. Are the pollution haven hypothesis (PHH) and environmental Kuznets curve (EKC) valid in sub-Saharan Africa?

In this thesis, we examine the motives for undertaking FDI in sub-Saharan Africa. Given the sustainability framework popularised by the Brundtland and World Commission on Environment and Development (1987) and the need to adopt a strong sustainability position for the discussion and implementation of the post-2015 sustainable development policies as opined by Pelenc et al. (2015), it is paramount that we devise ways of ensuring that the promotion of inward FDI does not harm the environment. This thesis contributes to the existing literature by assessing the relationship between FDI and environmental sustainability, specifically from sub-Saharan Africa's perspective.

In recent years, the relationship between FDI and environmental degradation has attracted enormous attention in the literature. Of particular concern is the pollution haven

hypothesis which states that MNEs will move their operations to less developed countries in order to take advantage of less stringent environmental regulations (Copeland and Taylor, 1994). In contrast, the pollution halo hypothesis posits that MNEs can export 'greener' technologies or 'greener' environmental standards from developed to developing countries in order to conduct business in an eco-friendly manner in host countries (Kim and Adilov, 2012). To date, it is unclear in the empirical literature whether FDI to sub-Saharan Africa has been eco-friendly. This study, therefore, explores the effect of inward FDI on the environmental sustainability of sub-Saharan Africa.

The originality of this thesis lies in the empirical application of the theoretical framework that allows investigating the structure and determinants of FDI and environmental sustainability in sub-Saharan Africa over the period 1985-2012. The findings from this thesis also contribute to the FDI and environmental sustainability literature, particularly for policy and future research purposes. The results provide new insights on the motives for international investment and implications for environmental sustainability to improve policy and practice.

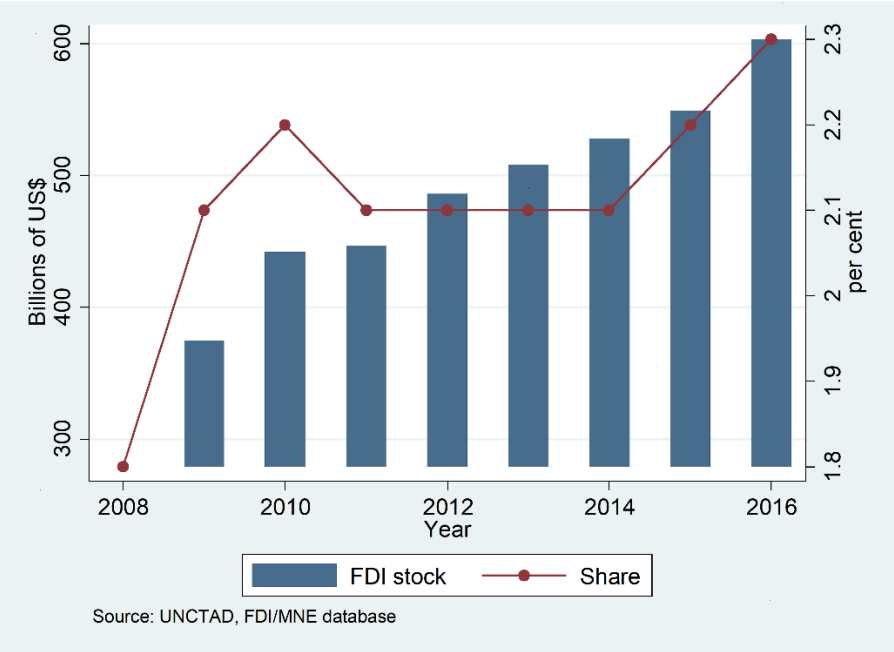
Prior to the development of the knowledge-capital (KC) model, a number of different frameworks have evolved (e.g., neoclassical trade theory, product life cycle theory, ownership, location and internalisation advantage framework) for analysing the determinants and motivations for FDI. However, in recent years the KC model has become the most articulate framework for explaining the location and production decisions of MNEs based on both horizontal and vertical motivations. In this framework, factor costs and market access are the driving force for the two main types of FDI: vertical and horizontal respectively. In addition, several variables have been identified as influencing patterns of FDI. In recent years, the stock of global inward FDI rose from US$11441 billion in 2005 to US$26728 billion in 2016, while the stock of global outward FDI increased more than twofold in 2016 from US$11902 billion in 2005.[1]

Further, the growth in FDI in sub-Saharan Africa slowed significantly in 2008 due to the global financial crisis, however, FDI recovered in 2012 despite a substantial variation in annual growth rate during the period. While FDI stock in sub-Saharan Africa has been increasing over time, the region's 2.3% share in global inward FDI is very small considering the huge untapped resources and economic growth potential in sub-Saharan

[1] Based on UNCTAD statistics database.

Africa. Therefore, it is important to understand the underlying determinants of FDI in order to guide economic policy formulation and implementation towards promoting FDI.

Figure 1 Sub-Saharan Africa inward FDI stocks and share in global FDI

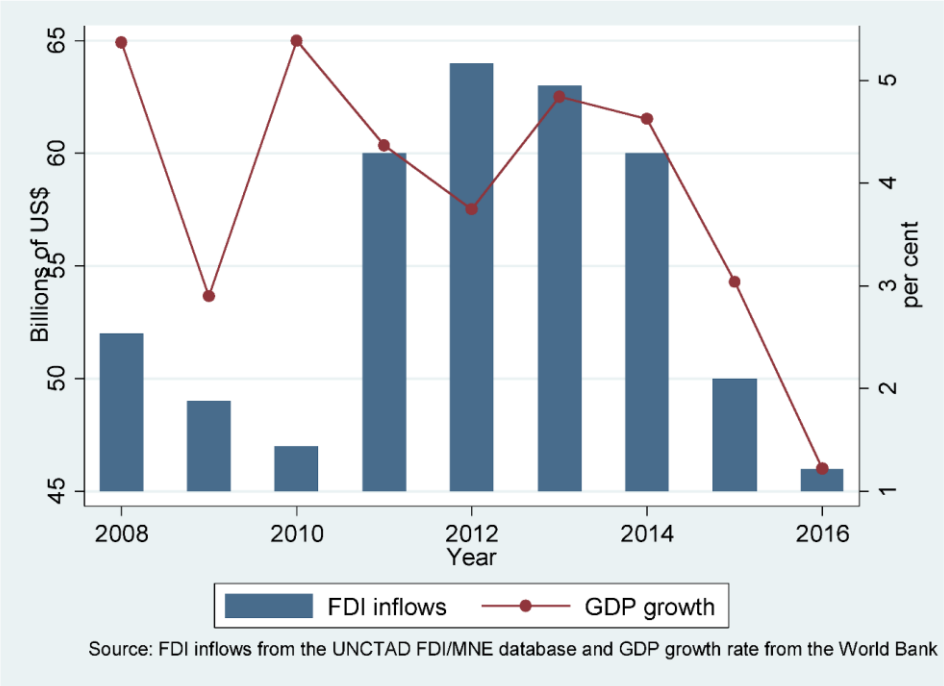


FDI performance in sub-Saharan Africa has not been stable over time. Regional FDI inflows reached their highest levels in 2012 with over US$64 billion but declined to US$46 billion in 2016 as a result of slow economic growth, low commodity prices and significant policy risks, as perceived by foreign investors (UNCTAD, 2017). Against this background, it could be worthwhile to examine the factors that might improve the attractiveness of sub-Saharan African countries as locations of FDI.

Sub-Saharan Africa is a very diverse region in terms of GDP and population, with a population of over one billion and a GDP of more than US$1614 billion, it offers a large and growing market for FDI (Regional Economic Outlook, 2012). According to the World Economic Forum (WEF), sub-Saharan Africa is characterised by less stringent environmental regulations. Furthermore, over the years sub-Saharan African countries have witnessed tremendous structural reforms to boost their economic growth and development. In particular, the period of review corresponds with the reform era when many sub-Saharan African countries adopted the structural adjustment programs (SAP) mainly based on the neoliberal "Washington Consensus". SAP reforms were designed to liberalise inward FDI and trade among others but due to the lack of enabling conditions such as good governance and political commitment from national governments, sub-Saharan African countries were

unsuccessful in attracting productive FDI. Despite this, there is still a lack of comprehensive empirical research on the determinants of FDI which focused exclusively on the region. Thus, it could be useful to examine whether environmental regulations and structure reforms matter for sub-Saharan Africa's inward FDI.

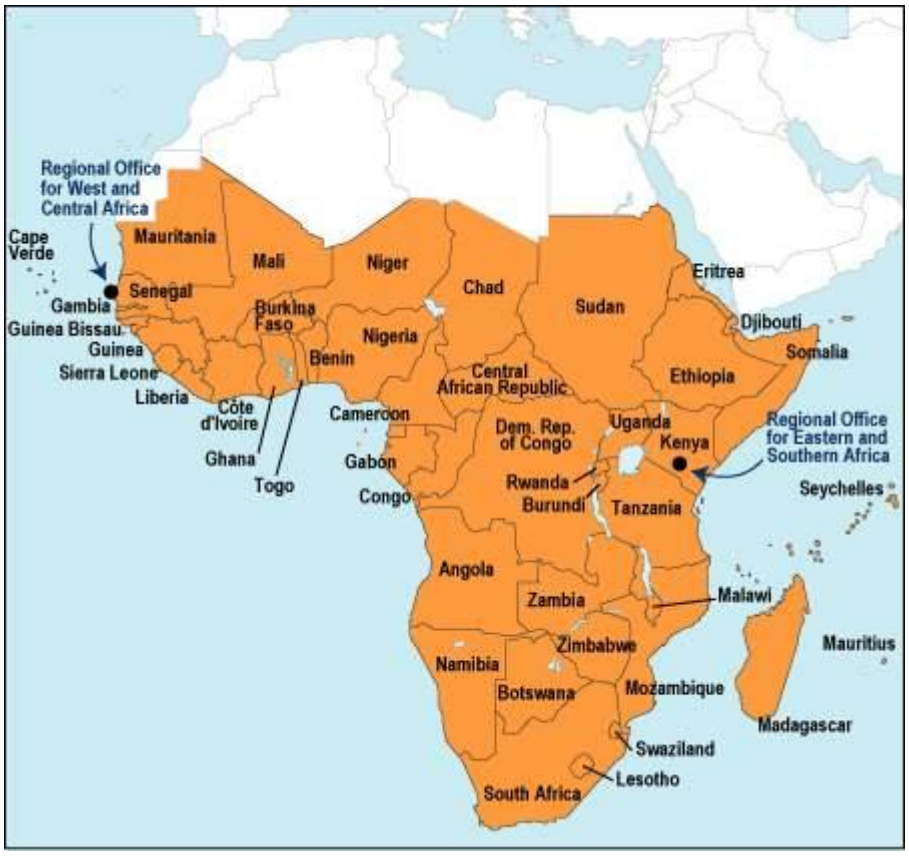
Figure 2 Sub-Saharan Africa FDI inflows and GDP growth rate



Sub-Saharan African countries are aggregated into four nonoverlapping groups based on per capita gross national income and the World Bank's institutional quality indicator. Although there are 45 sub-Saharan African countries, this study covers those countries in which data are available for the period under review.

The oil exporters are countries where oil is predominantly important as an export commodity that the evolution of world oil prices plays a major role in driving economic development. Countries in this group are Angola, Cameroon, Chad, Equatorial Guinea, Gabon, Nigeria, the Republic of Congo, and South Sudan. Using the World Bank Atlas method, the middle-income countries include economies which during the years 2013-2015 had per capita gross national income of more than US$1025. Countries in this group are Angola, Cameroon, Botswana, Cape Verde, Equatorial Guinea, Gabon, Ghana, Kenya, Lesotho, Mauritius, Mauritania, Namibia, Nigeria, the Republic of Congo, São Tomé and Principe, Seychelles, South Africa, Swaziland, Senegal and Zambia.

Figure 3 Map of Sub-Saharan Africa



Source: www.eoi.es

Low-income countries had an average per capita gross national income during 2013-2015 equal to or less than US$1025 using the World Bank Atlas method. Countries in this group include Benin, Burkina Faso, Central African Republic, Chad, Comoros, Eritrea, Ethiopia, the Gambia, Democratic Republic of Congo, Liberia, Madagascar, Malawi, Mali, Mozambique, Niger, Rwanda, Sierra Leone, South Sudan, Tanzania, and Uganda.

Fragile countries have a relatively low institutional quality. Economic development in these countries is heavily influenced by non-economic events such as the outbreak of civil conflict or subsequent recovery. Countries currently in this group are Burundi, Central African Republic, Comoros, Democratic Republic of Congo, Cote d'Ivoire, the Republic of Congo, Eritrea, Guinea, Guinea-Bissau, Liberia, São Tomé and Principe, South Sudan, Togo, and Zimbabwe.

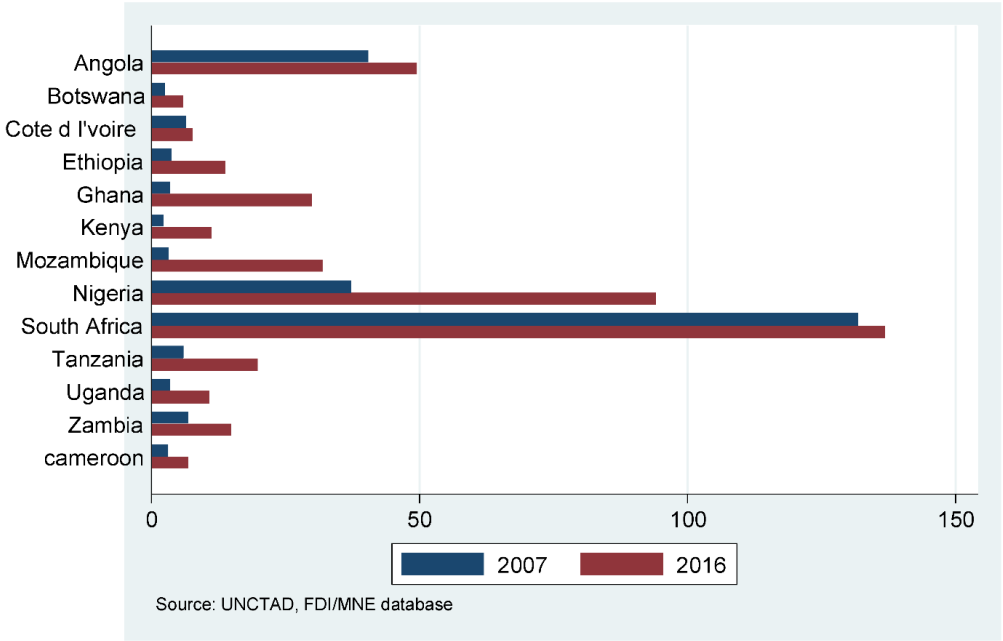
Table 1 Sub-Saharan African countries groupings

Oil-exporting countries	Middle-income countries	Fragile countries	Low-income countries
Angola Cameroon Chad Equatorial-Guinea Gabon Nigeria The Republic of Congo South Sudan	Angola Cameroon Botswana Cape Verde Equatorial-Guinea Gabon Ghana Kenya Lesotho Mauritius Mauritania Namibia Nigeria The Republic of Congo São Tomé and Principe Seychelles South Africa Swaziland Senegal Zambia	Burundi Central African Republic Comoros Democratic Republic of the Congo Cote d'Ivoire The Republic of Congo Eritrea Guinea Guinea-Bissau Liberia São Tomé and Principe South Sudan Togo Zimbabwe	Benin Burkina Faso Central African Republic Chad Comoros Eritrea Ethiopia The Gambia Democratic Republic of Congo Liberia Madagascar Malawi Mali Mozambique Niger Rwanda Sierra Leone South Sudan Tanzania Uganda

Source: World Bank/IMF database, 2016.

In summary, this thesis empirically analyses the motives for undertaking FDI in sub-Saharan Africa and the link between FDI and environmental sustainability during the period 1985-2012. Some studies examine firm location decisions (Forslid et al., 2018), while others study foreign investment (Rodriguez-Pose and Cols, 2017). In order to achieve our research goal and identify the structure and determinants of inward FDI and its role as a crucial factor for economic development and even for sustainable development, this thesis employs international macro-level data across sub-Saharan Africa.

Figure 4 Sub-Saharan Africa inward FDI stocks, top host countries (billion $)



The thesis is comprised of three empirical studies presented in different chapters. Chapter 1 examines the structure and motives for undertaking FDI in sub-Saharan African countries by MNEs from OECD countries in order to validate the theoretical predictions of the modified KC model of MNEs in sub-Saharan Africa. Chapter 2 analyses the relationship between environmental regulatory stringency and inward FDI while controlling for structural reforms such as financial and trade liberalisation as well as privatisation of state-owned enterprises. Other important factors that could influence FDI location decisions in sub-Saharan Africa are also analysed. Chapter 3 conducts a comparative analysis of the relationship between FDI and environmental sustainability measured by CO_2 emissions in Nigeria and South Africa based on the extended STIRPAT model with the aim to provide novel insights on the PHH and EKC theory. Finally, the conclusion, policy implications and guidelines for future research in the last chapter.

Chapter 1

The Determinants of FDI in Sub-Saharan Africa: An Analysis of the Knowledge-Capital Model

Abstract

This paper examines the determinants of foreign direct investment (FDI) in sub-Saharan Africa. Using a dynamic panel estimator, we empirically analyse bilateral inward FDI stocks between OECD countries and sub-Saharan African countries during the period 1985-2012. We extend the knowledge-capital (KC) model of multinational enterprises (MNEs) by controlling for corruption, structural reforms and environmental regulatory stringency. The results find evidence for both horizontal and vertical FDI. This suggests that market access plays an important role in the structure of sub-Saharan Africa inward FDI. The structure of the region's inward FDI indicates an interaction between relative factor endowments and market size differences that is consistent with vertical FDI motives. Trade and investment costs in sub-Saharan African countries are significant determinants of inward FDI. We find some evidence of a pollution haven in sub-Saharan Africa. These empirical results provide new insights to policymakers in shaping sound macroeconomic, structural and environmental policies for sustainable economic development.

1. Introduction

Over the last twenty years, there has been an increasing integration of the global economy. The interest in multinational enterprises (MNEs) has grown considerably due to the substantial growth in foreign direct investment (FDI), the defining activity of MNEs, outstripping the rate of growth of both international trade and world output.[2] The role of FDI in the financial globalisation process has motivated contentious debates in the academic and policy sectors, particularly with respect to environmental sustainability. FDI arises from decisions of MNEs either to capture local markets abroad through horizontal investments in similar products (Horstmann and Markusen, 1992; Markusen, 1984) or to take advantage of lower production costs abroad through vertical investments in labour-intensive production stages (Helpman 1984).

FDI involves an investor acquiring substantial control and interest in a foreign enterprise or setting up a subsidiary in a foreign country (OECD, 1996). Over the past two decades, FDI inflows have rapidly increased in almost every region of the world (UNCTAD, 2012). For developing countries, FDI remains the largest and most constant external source of finance, relative to private capital flows such as portfolio investments, bank loans, official development assistance (ODA), and international remittances (UNCTAD, 2017). Furthermore, FDI is less volatile than other types of capital flows (Noorbakhsh et al., 2001). FDI is widely understood to be the major catalyst for economic development and even for sustainable development. This study examines empirically the determinants of sub-Saharan Africa inward FDI from developed countries.

The volume of inward FDI in sub-Saharan Africa has witnessed a rising trend over the past three decades. The UNCTAD statistics indicate that total FDI into sub-Saharan Africa increased from US$248 million in 1980 to US$28.6 billion in 2017. The investment brought capital, management expertise and facilitated the transition process towards a market economy. However, in recent years sub-Saharan Africa's share of global FDI flows has declined from 2.3% in 2010 to 2% in 2017 due to a decreasing return on investment and policy uncertainty. It is therefore important for the region to increase its share of FDI in order to fill the resource gap, which can contribute to the economic growth and sustainable development of the host country.

[2] Based on UNCTAD statistics database.

Apart from being a source of finance and employment, FDI may induce positive spillovers that arise from international trade integration, such as technology transfer, productivity gains, the introduction of new processes and managerial skills, thereby stimulating economic growth and poverty alleviation (OECD, 2002). In contrast, FDI may also be considered as one of the major factors responsible for environmental degradation because faster economic development driven by FDI may exert pressure on a country's natural resources and the environment (Omri, 2014; Kim and Adilov, 2012).

Although the determinants of FDI has been extensively studied, there is a lack of consensus on a general framework. One framework within which to empirically examine the determinants of FDI is the knowledge-capital (KC) model (Carr et al., 2001; Markusen, 2002). This approach is referred to as the KC model because it assumes that knowledge is geographically mobile and has a joint input or public good property to multiple production facilities, i.e., once created, it can be supplied to foreign production facilities at a relatively low additional cost. It incorporates in one model, factor costs and market access as the driving force for the two main types of FDI: vertical and horizontal respectively. Consequently, the KC model offers a well-developed set of testable hypotheses about the relationships between MNE activity and country characteristics such as market sizes and relative factor endowments (Markusen and Markus, 2002). Thus, depending on country characteristics, both types of FDI can arise endogenously within the KC model. For example, horizontal FDI would dominate when countries are similar in economic size and relative factor endowments and the existence of high trade costs. However, vertical FDI dominates if countries are different in relative factor endowments (Carr et al., 2001).

In particular, the KC model combines factor endowments such as skill endowments with complex economies of scale to explain FDI location decisions (Chellaraj et al., 2013). Horizontal FDI takes place if multinational firms produce the same product in multiple plants in different countries in order to avoid transportation costs and to get access to host country markets, and vertical FDI geographical fragments its production by stages and seek to benefit from relative factor endowments and differences in factor prices across countries (Carr et al., 2001). Because we are interested in the relationships between bilateral inward FDI in sub-Saharan Africa and country-specific characteristics (e.g., market sizes and relative factor endowments), the KC model is an appropriate framework to explore the structure of sub-Saharan Africa's inward FDI. Although the KC model has been widely

used in a number of empirical studies, only a limited number of studies have focused on developing countries (Gao, 2003).

Sub-Saharan Africa is of interest in the analysis of the KC model for several reasons. First, the region possesses diverse characteristics in terms of GDP and population, with a population of over one billion and a GDP of more than US$1.6 trillion in 2012. Furthermore, the region possesses an abundance of natural resources including oil, gold, diamonds and copper. Sub-Saharan Africa is also among the main exporters of agricultural products such as coffee, cocoa and sugar. This is particularly important in the analysis of horizontal and vertical FDI because the countries of sub-Saharan Africa offer a unique opportunity for exploring horizontal and vertical FDI in terms of proximity to markets, (cheap) labour and raw materials.

Second, economic activity has remained robust with an average annual growth rate of 5% and it is estimated that between 2018 and 2023, sub-Saharan Africa's growth prospects will be among the highest in the world, according to the International Monetary Fund. Examining the effect of changing economic conditions on inward FDI allows a better understanding of the structure of FDI. Third, the region's growing and youthful population, amidst an aging population in most other regions offer a large and growing market for FDI (Regional Economic Outlook, 2012; World Bank WDI, 2012). This implies that some investors may look at the sub-Saharan region as a new market on one hand, while on the other hand, other investors consider productivity gains arising from a dynamic labour force.

For most sub-Saharan African countries, attracting FDI has not been successful. Although there are untapped opportunities and return to investment may be substantial, key challenges are faced by foreign investors in sub-Saharan Africa. Some of the major factors cited include high risk, political instability, poor infrastructure for example power shortages, and diseases such as malaria and the Ebola outbreak. Further, the countries of sub-Saharan Africa are faced with severe economic and environmental challenges. Poverty headcount ratio at $1.90 a day (2011 purchasing power parity) in sub-Saharan Africa stood at 41% in 2015, the largest percentage of the population living in poverty in the world according to the World Development Indicators of the World Bank. Due to existing and rising poverty and other geographical constraints such as harsh climates, soils and habitat, the region has been identified to be the most vulnerable to climate change (Parry et al., 2007). The inflow of FDI into the region is of crucial importance for the success of their transformation and integration into the world economy.

In this paper, we explore the determinants of FDI in sub-Saharan Africa. The paper proposes a new empirical framework to analyse the underlying motives for undertaking FDI from countries in the OECD to sub-Saharan African countries. Given the trade and financial linkages between developed, emerging and developing economies (Campos and Kinoshita, 2010), and the role of FDI as a catalyst for economic development (OECD, 2002), it is worth examining sub-Saharan Africa's inward FDI. Also, this paper is timely and important because rigorous empirical research on the determinants of FDI in the region is limited and most existing studies are statistically limited (Blonigen, 2005). To our knowledge, ours is the first empirical differentiation between vertical and horizontal FDI within the context of sub-Saharan Africa. We will apply a modified KC model to explore the production, location and investment decisions of multinational enterprises in the region.

This study fills a gap in the literature with respect to the sub-Saharan African case and its contribution to the FDI literature is mainly empirical. In particular, the study employs the generalised method of moments (GMM) techniques that overcome some of the methodological concerns by considering the dynamic nature of investment decisions and correcting for potential biases associated with endogenous FDI determinants and unobserved country-specific heterogeneity in order to provide reliable results. Apart from one study by Awokuse et al. (2012) that considers the dynamic model of international investment, there is still a lack of empirical studies that consider the dynamic nature of FDI in the econometric modelling. This is an improvement on previous empirical studies of the KC model as most of the existing literature employs a static regression technique (e.g., Carr et al., 2001; Blonigen et al., 2003; Kalamova and Johnstone, 2011). In summary, this study contributes to the literature in the following ways:

First, we investigate whether the knowledge-capital (KC) model predictions are valid for sub-Saharan Africa. The analysis empirically examines at a macroeconomic level, FDI from developed countries to developing countries. Specifically, we utilise panel data of bilateral outward FDI stocks from 30 OECD parent countries to 28 sub-Saharan Africa host countries between 1985 and 2012.[3] Data availability reduces the number of countries used in the analysis. The KC model is the most articulate framework of bilateral FDI which allows the analysis to differentiate between different models of production fragmentation, hence, the two main types of FDI: horizontal and vertical FDI (Carr et al., 2001; Kalamova and Johnstone, 2011). Furthermore, the strong dependence of sub-Saharan countries on

[3] A complete list of the parent and host countries in our analysis is given in the Appendix.

their natural resources has been well documented in many studies in recent years (Okafor et al., 2015; Cleeve et al., 2015). It might be more pertinent to look at natural resource endowments in the region as an additional motivation for FDI when multinationals seek to improve access to raw materials for their production. Adopting the KC framework, we offer fresh insights into the effect of natural resource endowments on inward FDI location decisions in sub-Saharan Africa. The natural resource endowments variable is measured as the total of natural resource rents as a percent of GDP. The source of the data is from the World Development Indicators compiled by the World Bank.

Second, it has often been argued that FDI may be influenced by factors such as corruption, financial, economic reforms and environmental regulations (e.g. Javorcik and Wei, 2004). In an effort to account for important confounders, we, therefore, extend the KC model by adding governance and institutional quality measured by the control of corruption. This is a -2.5 to 2.5 indicator of governance performance collected by the World Bank, reflecting the "perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption as well as 'capture' of the state by elites and private interests" (Kaufmann et al., 2010, p. 6), with higher ratings indicating good control of corruption, governance and institutional quality.[4]

Furthermore, using a recently complied dataset, we assess the role of different structural reforms in influencing FDI decisions. Qualitative discussion on these possibilities is common, but careful empirical analysis has been greatly hindered by data scarcity. This paper developed three structural reforms to assess international investment. Following the existing literature (e.g., Campos and Kinoshita, 2010), we explicitly account for the role of financial reform (e.g., financial development and bank efficiency), trade reform and privatisation of state-owned enterprises. Financial development reflects the depth of the financial market measured as three variables: the ratio of liquid liabilities to GDP, the ratio to GDP of credit issued to the private sector by banks and other financial intermediaries, and the ratio of commercial bank assets to the sum of commercial bank assets and central bank assets. We follow Campos and Kinoshita (2010) to combine these variables to create the financial development indicator by normalising the variables and equating the maximum for all countries and variables.

[4] See the World Governance Indicators (WGI) database.

The bank efficiency indicator is built upon two variables: the ratio of overhead costs to total bank assets and the net interest margin. We follow the normalisation approach described above to combine these variables into a single indicator for the bank efficiency index. The source of the financial reform variables is from the World Bank Financial Structure Dataset (Beck et al., 2000).

Trade reform refers to measures aimed at reducing restrictions to trade. Trade reform comprises of two variables: the average tariffs (weighted by trade volumes) and standard deviations obtained from the Economic Freedom of the World dataset. We apply the normalisation process and calculate the arithmetic average of the two variables to obtain the trade reform indicator.

In order to quantify the effect of privatisation on inward FDI, we obtain World Bank's data on privatisation proceeds in sub-Saharan Africa. Privatisation proceeds refer to "all monetary receipts to the government resulting from partial to full divestitures (via asset sales or sale of shares), concessions, leases, and other arrangements" (Kikeri and Kolo, 2005, p. 2). The privatisation index is measured as the total privatisation proceeds as a percentage of GDP.

In addition, we examine whether environmental regulations affect the location and production decisions of MNEs. Following Kalamova and Johnstone (2011), we include the relative differences in environmental regulatory stringency between the parent and the host country, a variable often understated in the FDI literature. This paper contributes to the pollution haven hypothesis (PHH) literature, which has motivated lasting and inconclusive debates on the possible existence of "pollution havens". The PHH implies that multinational corporations tend to locate polluting industries in developing countries, which is generally characterised by relatively weaker environmental regulations. Moreover, since the stringency of environmental regulations increases with income (Dasgupta et al., 2001), this suggests that developing countries possess a comparative advantage in pollution-intensive production (Cole and Elliott, 2003). As one of the largest developing regions, sub-Saharan Africa also faces a trade-off between economic growth and environmental quality and is prone to become a pollution haven. As a result, sub-Saharan Africa is the perfect place to examine the PHH. To test the validity of the PHH in sub-Saharan Africa, this paper examines the effect of the difference between environmental regulatory stringency of the parent and host country on inward FDI from OECD countries.

This paper uses the measurement of environmental regulatory stringency obtained from the World Economic Forum's Executive Opinion Survey, which asked respondents a number of questions related to environmental policy design. The respondents of the Executive Opinion Survey are business leaders who routinely assess investment decisions. They were requested to measure the "overall stringency of environmental regulations" on a scale from 1 (lax compared with that of most other countries) to 7 (among the world's most stringent).

The benefit of using the World Economic Forum's measure of environmental regulatory stringency is that the Executive Opinion Survey has a wide coverage of developed and developing countries and conveys a subjective assessment of environmental regulatory stringency that reflects on business executives' own perception of the stringency of environmental regulation in a given country thereby providing a measure that is closer to reality than hard data which usually shows the "picture of the past", especially in those aspects that are difficult to quantify such as stringency of environmental regulations (Tang, 2015).

In order to address concerns of insufficient data, the previous literature suggests that environmental regulatory stringency be treated as a time-constant variable (see e.g. Wagner and Timmins, 2009; Kalamova and Johnstone, 2011). We employ mean values of environmental regulatory stringency for 58 parent and host countries. The variable ranges from 2.1 (Cote d'Ivoire) as its lowest to 6.5 (Sweden) as its highest value in the sample. In this paper, we apply the modified KC model of the multinational enterprise to explore the production, location and investment decisions in sub-Saharan Africa. In contrast to previous empirical studies that were based on the original KC model, this paper investigates whether in addition to the economic and geographical fundamentals of the KC model, natural resource endowments, institutional quality, macroeconomic structural reforms and relative environmental regulatory stringency have significant effects in attracting inward FDI from OECD countries to sub-Saharan Africa countries.

In summary, this paper examines the reasons for undertaking FDI in sub-Saharan Africa. The main contribution of this paper is that it provides the first empirical differentiation between vertical and horizontal FDI in the sub-Saharan African region. In addition, this paper analyses the effects of natural resource endowments, institutional quality, relative environmental regulatory stringency and structural reforms using recently compiled datasets. The empirical analysis provides strong evidence in support of a pollution

haven in sub-Saharan Africa. The findings suggest that improving environmental regulations, institutions and reforms in a host country is important to achieving sustainable development in developing countries, especially in sub-Saharan Africa.

The rest of this paper is organised as follows: section 2 provides the literature review, section 3 presents the methodology and data, section 4 discusses the results and section 5 presents the conclusion.

2. Literature Review

In recent years, the industrial-organisation approach to international trade also referred to as the "new trade theory" has incorporated endogenous multinational firms into traditional general-equilibrium trade models which are characterised by increasing returns to scale, imperfect competition and product differentiation (Carr et al., 2001). This approach has provided an alternative framework for analysing FDI and MNE activity by combining ownership and location advantages of firms with country characteristics. These firms are either horizontal or vertical MNEs.

Since Markusen (1984) and Helpman (1984), the general-equilibrium theory of MNEs has focused on two distinct motivations for FDI: to access markets to avoid transport costs and trade barriers (horizontal FDI) or to access low wages for labour-intensive aspects of the production process (vertical FDI). Thus, similarities in market size, factor endowments and transport costs are determinants of horizontal FDI, while differences in relative factor endowments determined vertical FDI.

The horizontal FDI model, which can be traced back to Markusen (1984), is based on the proximity-concentration hypothesis, in which MNEs set up multiple plants in different countries to produce similar goods and services in order to improve the access to host country markets. It places production close to customers in order to minimise trade costs. The model predicts that high trade costs will stimulate horizontal FDI as it becomes expensive for firms to export, hence, making local production more efficient.

The vertical model of FDI developed by Helpman (1984) is explained by the factor-proportions hypothesis. MNEs geographically fragment their production process into different stages in order to produce in multiple countries so as to locate production activities where the factors used intensively in these activities are cheap thereby seeking to benefit from international factor price differences that are based on differences in factor endowments and factor prices across countries. The model predicts that skilled-labour-

intensive production (e.g., headquarters services) will be located in the skilled labour abundant country while unskilled labour-intensive production (e.g., assembly processes) in the unskilled labour abundant country.

According to Markusen (2002), the KC model makes three principal assumptions and offer an appropriate framework to study empirically FDI. The services of knowledge-based and knowledge-generating activities (e.g., R&D) can be geographically separated from production and supplied to production facilities at a low cost. These knowledge-intensive activities are skilled labour intensive relative to production. These assumptions generate incentives for the vertical fragmentation of production, locating R&D activities where skilled labour is abundant and production where unskilled labour is abundant. Furthermore, it offers an incentive to locate production in large markets if there are scale economies at the plant level. The knowledge-based services or assets are joint inputs and may be used simultaneously at multiple production facilities which generate firm-level scale economies and supports horizontal investments in facilities that produce the same products in different locations.

Markusen (2002) argued that horizontal MNEs are predominant when countries are similar in size and relative endowments and transport costs are high. In this situation, MNEs will locate production facilities in both countries and headquarters in the home country. Furthermore, if countries are different in size, it is expected that the larger country would be the preferred location for production facilities in order to avoid costly capacity in the smaller country. Also, when countries are different in relative endowments there is an incentive to locate production in the skilled labour scarce country while headquarters in the skilled labour abundant country. This suggests that vertical MNEs are preferred when countries differ in relative endowments unless trade costs are high. More so, vertical MNE is prevalent if one country is small and skilled labour abundant, thereby, headquarters will be in the skilled labour abundant country and production in the other.

The knowledge-capital (KC) model which combines both the horizontal and vertical motives for FDI has been tested empirically. Carr et al. (2001) use data for the US and 36 other countries to investigate the validity of the KC model. The study provides evidence for both the horizontal and vertical motivations for FDI that is consistent with the model predictions. Markusen and Markus (2001) extended the empirical analysis of Carr et al. (2001) using only US data and found no evidence in support of the KC model. Markusen and Markus (2002) analysed data involving US FDI and a methodology that

distinguished between the horizontal model, the vertical model and the KC model. They integrated the horizontal and vertical models within an unrestricted KC model on both outward and inward foreign affiliate sales for the US and 36 other countries. The results indicate that the horizontal FDI model cannot be statistically distinguished from the unrestricted KC model thereby providing support for the horizontal model and the KC model but not for the vertical model suggesting that a large proportion of world FDI is from high income developed countries to other similar high income developed countries.

Yeaple (2003) examined US outward FDI and found evidence for both vertical and horizontal motivations. The result suggests that factor endowment differences increase FDI for industries that intensively use the factor in which the host country has a comparative advantage. Blonigen et al. (2003) argued that the results in Carr et al. (2001) may be due to model misspecification. They pointed out that the empirical framework used by Carr et al did not adequately specify the proxy for relative skilled labour abundance. They estimated a corrected version of the model that used absolute values of skilled labour abundance differences in addition to absolute values of GDP differences. Using the same dataset from Carr et al. (2001), they find support for the horizontal model and not the vertical model, hence rejecting the KC model. The results suggested that MNE activity was smaller the more countries differed in relative factor endowments.

In response to the aforementioned papers, Davies (2008) re-estimated the KC model using Carr et al. (2001) US data and Blonigen et al. (2003) expanded US and OECD data. Davies modified the KC model by introducing the squared term of the skill difference between the parent and host countries in order to allow a non-monotonic relationship between FDI and skill difference suggested by the KC model in Carr et al. (2001) specification. The results support the KC model even when using the same datasets. In addition, Davies suggests that an appropriate specification to test the simultaneous existence of horizontal and vertical MNEs may depend on measures of FDI activity and the skill variable used which increases the importance of other types of countries in the datasets. For example, Carr et al. (2001) use job classifications to proxy for a country's skill level and sales by foreign affiliates as proxy for FDI activity in the US, whereas Blonigen et al. (2003) use a country's mean years of education and the OECD dataset on stock of FDI, which provided a broader collection of partner countries, including developing countries.

Other studies proposed different empirical approaches for the KC model. Braconier et al. (2005) analysed bilateral affiliate sales data for 56 home countries and 85 host

countries and found strong support for the KC model. They argued that previous studies found mixed evidence on the KC model particularly with regards to the vertical FDI model partly because they used limited data that do not provide observations where vertical FDI is more likely to occur. Also, they argued that a common practice in the prior literature was to use a measure of skill that became increasingly biased as the home country skill intensity increases thereby explaining the weak empirical evidence on the KC model from previous studies. Awokuse et al. (2012) examined US affiliate sales to 39 FDI-recipient countries and local affiliate sales for all manufacturing industries and other sectors as well as US exports. They found support for the horizontal model of FDI for a number of sectors including food manufacturing and chemicals. Also, support for the vertical motives for FDI was found for foreign affiliate sales and exports in food products and electronic while the machinery sector was explained by primarily horizontal motivations. The transportation equipment industry showed more vertical fragmentation as a result of skilled labour differences across host countries. The result suggests that the predictions of the KC model in explaining MNE behaviour vary by the type of industry.

Kalamova and Johnstone (2011) empirically analysed the determinants of outward OECD FDI from 27 OECD countries to 99 developed and developing host countries. They provided results that are consistent with the KC model predictions. In addition, they focus on differences in environmental regulatory stringency between the parent and host country and the results indicate that relatively less stringent environmental regulation in the host country is found to play an important role in FDI flows, and their approach is thus similar to ours. Lankhuizen (2014) analysed data for 15 OECD source countries and 44 OECD and non-OECD host countries and specified the KC model in which source and host country relative skill endowments are estimated separately and provides evidence that skill differences are important in explaining FDI in line with the prediction of the KC model. Dauti (2016) examined bilateral FDI stock between 20 OECD countries and 5 Southeast European countries and 10 new EU member states during the period 1994-2010, provide mixed evidence in support of vertical FDI for new EU member states and horizontal FDI for Southeast European countries. In a more recent study, Stack et al. (2017) assessed the determinants of FDI in the eastern European countries within the KC model framework using a panel of bilateral FDI stocks from 10 western European countries to 10 eastern European countries during the period 1996-2007. They provide evidence for both vertical and horizontal motives of FDI suggesting a shift over time towards the latter. Cieslik (2017) examined FDI motivations in Poland using a bilateral panel dataset of the number of firms

with foreign capital from the old 15 EU countries over the period 1989-2014, suggesting that both vertical and horizontal FDI are important.

Using inward and outward investment between Singapore and a sample of industrialised and developing countries, Chellaraj et al. (2013) found that inward investment from the industrialised countries shifted from a modestly vertical motivation to a strong skill-seeking behaviour as a result of Singapore's rapid growth in skills endowment while its investments in developing countries were concentrated in labour-seeking production. The results suggest that inward and outward manufacturing investments between Singapore and industrialised countries supported the horizontal model while inward and outward manufacturing investments with developing countries were driven by vertical motivations. Furthermore, they argued also that the mixed results from previous studies are due partly to the selection of countries as most studies did not consider data for lower-income developing countries. However, the KC model has been used in a study by Gao (2003) which provided empirical evidence for both horizontal and vertical FDI in China. They argued that FDI is positively related to differences in relative skilled labour abundance between the source country and the host country, in this case, China, and positively related to the combined size of the source country and China. The results are in line with the KC model predictions and intuitively provide a good fit for the current economic conditions in China.

In summary, within the body of the empirical literature, no study has focused exclusively on sub-Saharan Africa when investigating the determinants of inward FDI from developed countries to the region. This study contributes to the literature by examining the KC model from a developing country's perspective. Our approach uses a dynamic panel estimator to examine FDI from 30 OECD parent countries to 28 sub-Saharan Africa host countries from 1985 to 2012. Empirical studies showed that natural resource endowments, structural reforms such as financial sector development, trade liberalisation and privatisation of state-owned enterprises, environmental regulations and institutional quality could be potential determinants of FDI and should therefore be incorporated into the theoretical models explaining FDI (Faeth, 2009; Campos and Kinoshita, 2010; Kalamova and Johnstone, 2011; Javorcik and Wei, 2004).

3. Methodology and Data

We start by drawing from the existing literature following the basic specification set out in Carr et al. (2001) as follows:

$$FDI_{ijt} = \beta_0 + \beta_1 GDPSUM_{(i,j)t} + \beta_2 (GDPDIFFSQ_{(i,j)t}) + \beta_3 SKILLDIFF_{(i,j)t} + \beta_4 (\{SKILLDIFF_{(i,j)t}\} * \{GDPDIFF_{(i,jt)}\}) + \beta_5 INVC_{jt} + \beta_6 TC_{jt} + \beta_7 (\{SKILLDIFFSQ_{(i,j)t}\} * \{TC_{,jt}\}) + \beta_8 TC_{it} + \beta_9 DISTANCE_{ij} + \varepsilon_{ijt} \quad (1)$$

where *i* represents the parent country (i.e., an OECD country) of the MNE, defined as the country where the headquarters of the MNE is located, and *j* is the host country (i.e., a sub-Saharan African country) defined as the country where the foreign affiliate of the MNE is located. Subscript *t* indicates year.

The dependent variable FDI_{ijt} measures real bilateral FDI stock from the parent country *i* to the host country *j* in year *t*. Since there is no comprehensible cross-country database on foreign investment, we collected data on OECD member countries' bilateral FDI stock in sub-Saharan African countries to capture foreign affiliate sales activity (Blonigen et al., 2003). Focusing on stocks instead of FDI flows may actually be an advantage, for stocks are long term decisions to invest and are less volatile, and less dependent on missing variables, than FDI flows (Braconier et al., 2005). These data were obtained from the OECD International Direct Investment Statistics Yearbook.

We converted FDI into millions of real FDI using the US GDP deflator as reported in the Federal Reserve Economic Database.[5] It is often used to reduce the effect of price changes, i.e., to adjust for inflation. The data for explanatory variables were obtained from various sources. Definitions and sources of variables used are given in the Appendix. The variable GDPSUM is the sum of real gross domestic product (GDP) in the parent country and host country and captures the horizontal motive for FDI. This reflects the total of bilateral market size and we hypothesize that FDI should be positively related to GDPSUM because growth in total demand will lead to a switch from high marginal-cost single-plant production to high fixed-cost multi-plant production (scale economies) thereby increasing FDI (Markusen and Maskus, 2001).

To account for the fact that market size differences have a nonlinear effect on FDI, the square of GDP difference is added to the model. GDP difference square (GDPDIFFSQ) is the squared difference in real GDP between the parent and the host country. The coefficient on GDP difference square (GDPDIFFSQ) is expected to be negative because

[5] Available at https://fred.stlouisfed.org/series/USAGDPDEFAISMEI.

the KC theory suggests that there is an inverted U-shaped relationship between affiliate sales and differences in country size (Carr et al., 2001). This implies that incentives for market-seeking (horizontal) investment should increase as countries become more similar in size (Chellaraj et al., 2013). Data for real GDP were obtained from the Penn World Tables.[6]

The skill difference variable (SKILLDIFF) measures skill differences between the parent and the host country. To capture this concept, and following Blonigen et al. (2003), we employ average educational attainment as a proxy for skilled labour abundance. This was obtained from the Penn World Tables using average years of schooling for the population aged 15 and over (Barro and Lee, 2013). For years where data are unavailable, we resort to Cohen and Soto (2007) and Cohen and Leker (2014) alternative dataset for average years of schooling. Hence, our skill difference (SKILLDIFF) variable is the average years of schooling of the parent country minus the average years of schooling of the host country.

Furthermore, the skill difference term is the key variable in the KC model for distinguishing vertical FDI within the aggregate FDI (Markusen and Markus, 2002). The coefficient on skill difference (SKILLDIFF) is expected to be positive because firms tend to locate their headquarters (services) in the skilled-labour-abundant country and plant facilities (production) in the skilled-labour-scarce country. Therefore, an increase in skill difference should raise incentives for vertical FDI, implying a positive coefficient. In addition, in order to address the issue of misspecification pointed out by Blonigen et al. (2003), we employ an absolute value KC model.[7]

To capture the influence of vertical FDI and the nonlinearities implied in the KC model, we include the same interaction term variable between skill difference and GDP difference (SKILLDIFF*GDPDIFF). This variable is expected to capture the idea that an increase in skill difference and differences in market size could encourage vertical FDI and reduce horizontal FDI. This is because vertical multinational firms should be associated with differences between countries in both market size and in relative factor endowments. This implies that as the parent and host countries become increasingly different in skills and market size, they tend to have greater motivation for vertical FDI. We expect a negative

[6] Available at https: //fred.stlouisfed.org/categories/33402.

[7] In their comment on the estimation of the KC model, Blonigen, et al. (2003) argued that it is incorrect to estimate a pooled coefficient of a difference variable that takes both positive and negative values in the data, thereby motivating the use of absolute values of the difference terms.

coefficient, suggesting a decrease in horizontal FDI which is driven by similarities in skills and market size.

The variable investment costs in the host country (INVC) measures the costs of investing in the host country. Following Carr et al. (2001), the cost of investing in the host country is defined as an average of several indices of perceived impediments to investment. This is based on extensive surveys of MNEs as reported in the Global Competitiveness Report of the World Economic Forum which includes restrictions on the ability to acquire control in a domestic company, limitations on the ability to employ foreign skilled labour, restraints on negotiating joint ventures. Also included are strict controls on hiring and firing practices, market dominance by a small number of enterprises, an absence of fair administration of justice, difficulties in acquiring local bank credit, restrictions on access to local and foreign capital markets, and inadequate protection of intellectual property. The resulting investment costs index is scaled from zero to 100, with a higher number indicating higher investment costs. This is expected to have a negative impact on FDI because high investment costs deter FDI.

The variable trade costs in the host country (TC_j) captures the notion of trade costs in the host country and is an index of trade barriers. We use the trade openness measures from the World Development Indicators compiled by the World Bank, which is measured as the sum of exports and imports divided by the country's GDP. In a similar approach to Blonigen (2003), we define trade costs as 100 minus trade openness measures with a higher number meaning more openness. The coefficient is expected to be positive because high trade costs stimulate horizontal FDI. In contrast, trade costs (TC_i), defined as the parent country trade costs, is expected to have a negative impact on FDI because high trade cost should make exporting back to the parent country more expensive. The interaction variable skill difference squared and trade costs in the host country (SKILLDIFFSQ*TC_j) captures the fact that high trade costs in the host country may encourage horizontal FDI while diminishing vertical FDI given that the incentives for horizontal FDI are strongest when relative skill endowments are similar (Awokuse et al., 2012). Therefore, for a given level of host country trade costs, an increase in endowment differences should reduce horizontal FDI and the coefficient should be negative. However, Carr, et al. (2001) are agnostic about

the sign of this variable because there is a trade-off between trade costs and relative skill endowments, however, they suggest a weakly negative impact.[8]

The variable $DISTANCE_{ij}$ is defined as the geographical distance measured as the number of kilometres between the capital cities of the parent and host country. Data for this variable is taken from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII). According to Carr et al. (2001), the sign of this variable is ambiguous in theory, because distance is a component of both export costs and investment costs. In the former case, a positive coefficient is expected because distance encourages the substitution of exports by FDI, while in the latter, the coefficient will be negative because higher investment costs reduce FDI.

In this study, we extend the KC model by including other determinants of FDI. For example, Cleeve et al. (2015) show that natural resource endowments play a significant role in influencing inward FDI. Javorcik and Wei (2004) presents evidence that an increase in corruption decreases FDI; Campos and Kinoshita (2010) argue that structural reforms play a crucial role in FDI; Kalamova and Johnstone (2011) find that environmental regulatory stringency difference between the parent and host country significantly increases FDI, however, this effect reduces as the host country's stringency becomes extremely lax.

Adding these variables, the model is given as follows:

$$FDI_{ijt} = \beta_0 + \beta_1 X_{ijt} + \beta_2 NRESOURCE + \beta_3 CORRUPT_{jt} + \beta_4 SREFORMS_{jt} + \beta_5 ERSDIFF_{ijt} + \varepsilon_{ijt} \quad (2)$$

where FDI_{ijt} is the real value of bilateral FDI stock from the parent country i to the host country j respectively during year t while ε is the error term and β are vectors of coefficients. X_{ijt} denotes the fundamental KC model variables comprising the economic and geographical conditions of parent and host countries as defined in Equation (1).

In Equation 2 we control for additional determinants of FDI. The first variable is natural resource endowments (NRESOURCE) as a driver of FDI. It is measured as total natural resources rents as a percentage of GDP. Data on this variable was obtained from the

[8] Host country trade costs affect only horizontal MNEs. Furthermore, horizontal MNEs occur when countries are similar in endowments. Carr, et al. (2001) therefore suggest that skill difference squared and trade costs in host country (SKILLDIFFSQ*TCj) has a negative impact, but simulation results show a complicated interaction and they conclude that this is not a "theoretically sharp hypothesis".

World Development Indicators developed by the World Bank. We expect a positive coefficient for this variable because countries with large endowments of natural resources tend to attract more FDI, especially natural resource-seeking FDI (Anyanwu, 2012).

Further, $CORRUPT_j$ reflects the host country *j*'s institutional quality and governance. This variable is from the World Bank Governance Indicators (Kaufmann et al., 2010) and ranges from -2.5 to 2.5, with a higher value indicating lower corruption. We conjecture that an improvement in governance and institutional quality is expected to reduce corruption and improve investment conditions, thereby attracting inward FDI.

Finally, $SREFORMS_j$ is the vector of measures to capture structural reforms in the host country. Following the existing literature (such as Campos and Kinoshita, 2010), we considered the most important reforms that may attract FDI, and we define structural reforms as a combination of financial reform, trade reform and privatisation. It is important to note that a substantial amount of the value of privatisations in the region during the 1990s took place in the infrastructure sectors. The composition of privatisation by sectors differs between countries. For instance, in Mozambique, where a substantial amount of privatisation occurred in the region, over 80 percent of this privatisation was in the manufacturing and services sector.[9]

The primary aims of the financial reforms adopted in the host countries have been to achieve greater financial liberalisation of markets and regulations. We include two measures to reflect financial liberalisation in the region, namely: financial sector development which captures the depth of financial markets and bank efficiency which indicates the efficiency of the banking sector. Financial sector development is measured using three variables: the ratio of liquid liabilities to GDP, the ratio to GDP of credit issued to the private sector by banks and other financial intermediaries and the ratio of commercial bank assets to the sum of commercial bank assets and central bank assets. Bank efficiency is based on two variables: the ratio of overhead costs to total bank assets and the net interest margin (Beck, et al., 2000)[10]. The index is measured on a scale of 0 to 1.

Although trade openness is commonly used in studies of trade liberalisation, however, in this paper, trade liberalisation is measured as a combination of the average tariff rate and tariff dispersion for countries in our sample. In so doing we are able to

[9] Available on the World Bank privatisation database.

[10] The source of the financial reform variable is the June 2016 version of the World Bank's Financial Structure dataset.

differentiate reform efforts from reform outcomes. For instance, improvements in trade openness may be a result of other factors such as exchange rate regime, climate shocks, technological change or fluctuations in the trade policy of major trading partners.[11] The tariff rate is designed to measure restraints affecting international trade and to capture a country's tariff policy. For example, in 2016 countries like Cote d'Ivoire and Ghana have a uniform tariff structure with an average tariff of 7.56 percent and a tariff dispersion of 7.02. On the other hand, countries can have different tariff structures. For example, Tanzania and Swaziland have an average tariff of 7.42 and 8.48 percent respectively, with a standard deviation of 5.10 and 5.56 respectively. The average tariff is calculated as the mean applied ad-valorem duty across tariff lines and the tariff dispersion is the standard deviation of tariffs around their mean values. We normalise these variables by subtracting the actual value from the minimum in the numerator so that the larger value indicating more trade reform efforts. We then took the mean values of the average tariff rate and the tariff dispersion to obtain the trade reform index. The index is measured on a scale of 0 to 1. These variables were obtained from the Heritage Foundation's Economic Freedom of the World (Gwartney, et al., 2000).

The third variable is designed to capture the notion of state-owned enterprises which is measured as all privatisation proceeds in sub-Saharan African countries measured in millions of US Dollars. By using this indicator, we capture the government privatisation efforts. Privatisation proceeds are defined as all government revenues from privatisation resulting from partial and full divestitures through the sale of shares or asset sales, concessions, leases, and other arrangements. However, this excludes management contracts, green-field investments and investments made by new private operators as part of concession agreements as well as all those transactions with a foreign buyer. The privatisation variable is measured as total privatisation proceed as a percentage of GDP. The source of this data is the World Bank privatisation database (Kikeri and Kolo, 2005). It is expected that overall structural reforms should have positive effects on inward FDI. A complete definition and construction of the structural reforms' variables are provided in the Appendix.

The variable $ERSDIFF_{ijt}$ is the difference in environmental regulatory stringency between the parent and the host country. Following Wagner and Timmins (2009) and Kalamova and Johnstone (2011), the measure of environmental stringency in this paper is

[11] Campos and Kinoshita (2010) also make this important point.

taken from the Executive Opinion Survey conducted by the World Economic Forum (WEF). In the survey, respondents, usually, individuals who routinely assess and make investment decisions, were requested to indicate the stringency of a country's overall environmental regulation on a Likert scale of 1 to 7 where 1 is lax compared with that of most other countries and 7 is among the world's most stringent. Due to data availability, this paper uses the mean values for the period of the analysis. We expect that the higher the relative environmental regulatory stringency, the greater the comparative advantage and the higher will be the inward FDI.

A complete description of definitions of all variables and data sources are provided in the Appendix. The summary statistics are given in Table 2.

Table 2 Summary statistics

Variables	**Mean**	**Standard deviation**	**Minimum**	**Maximum**	**N**
Real FDI (millions of US$ at 2011 price)	4.651	17.2	-7.362	257	2510
GDP sum (billions of US$ at 2011 price)	3527.252	4553.26	16.239	16740.13	2745
GDP difference (millions of US$ at 2011 price)	3282.204	4591.006	0.690	15858.04	2745
GDP difference squared (billions of US$ at 2011 price)	31.8	68.1	0.476	251	2745
Skill difference (number of years)	7.004	2.431	0.049	12.425	2745
Skill difference squared (number of years)	54.965	34.165	0.002	154.378	2745
Investment costs host (0-100)	93.557	1.734	90	96.9	2745
Trade costs host (0-100)	30.952	28.558	-104.901	88.254	2724
Trade costs parent (0-100)	34.116	33.185	-70.428	81.651	2745
Distance (km)	7934.091	2820.44	3487.838	15222.4	2745
Natural resource endowments (% of GDP)	9.961	9.309	0.004	56.609	2745
Institutional quality (-2.5-2.5)	-0.48	0.586	-1.379	0.979	2745
Financial development (0-1)	0.559	0.249	0	1	2745
Bank efficiency (0-1)	0.381	0.246	0	1	2745
Trade reform (0-1)	0.656	0.291	0	1	2745
Privatisation (% of GDP)	0.055	0.255	0	3.752	2745
Stringency difference (1-7)	1.877	0.856	0	4.3	2745

The empirical analysis focuses on panel datasets comprising 58 countries of which 30 OECD parent countries and 28 sub-Saharan host countries over the period 1985-2012. Table 3 presents the correlation coefficients of all variables used in the analysis.

Table 3 Correlation matrix

Variables	Real FDI	GDP sum	GDP diff sq.	Skill diff	ICH	TCH	TCP	DIST	NRE	INQ	FD	BE	TR	PS	SD
Real FDI	1.000														
GDP sum	0.079	1.000													
GDP difference squared (GDP diff sq.)	0.045	0.979	1.000												
Skill difference (Skill diff)	-0.026	0.343	0.337	1.000											
Investment costs host (ICH)	-0.084	0.033	0.020	-0.084	1.000										
Trade costs host (TCH)	-0.000	-0.057	-0.070	0.153	0.057	1.000									
Trade costs parent (TCP)	0.052	0.611	0.525	0.113	0.020	0.009	1.000								
Distance (DIST)	0.069	0.484	0.482	-0.013	-0.115	-0.164	0.209	1.000							
Natural resource endowments (NRE)	0.054	0.004	0.003	0.245	-0.091	-0.140	0.003	-0.167	1.000						
Institutional quality (INQ)	0.040	-0.003	0.001	-0.423	0.021	-0.186	-0.002	0.321	-0.470	1.000					
Financial development (FD)	0.049	-0.072	-0.037	-0.134	0.025	-0.055	-0.181	0.053	-0.046	0.283	1.000				
Bank efficiency (BE)	-0.078	0.071	0.055	0.186	0.045	0.038	0.117	-0.114	0.132	-0.067	-0.175	1.000			
Trade reform (TR)	0.023	-0.030	0.005	-0.062	0.027	0.052	-0.152	-0.077	-0.005	0.096	0.303	-0.088	1.000		
Privatisation (PS)	-0.028	0.007	0.001	0.006	0.024	0.071	-0.006	-0.050	-0.042	-0.000	-0.056	0.063	0.043	1.000	
Stringency difference (SD)	-0.041	-0.045	-0.025	0.450	0.031	-0.087	-0.211	-0.273	0.227	-0.436	-0.241	0.081	-0.071	0.043	1.000

We include all countries in OECD and sub-Saharan Africa in which data is available. For example, Luxembourg is not included in the list of OECD parent countries because it is known to be a large channel of indirect FDI. For example, restive sub-Saharan African countries where data was insufficient to include in the analysis were Central African Republic, Guinea Bissau, South Sudan, and Eritrea. It is worth noting that there are some years with zero and negative FDI observations. According to the OECD FDI statistics, negative FDI stocks mainly occur when the loans from the foreign affiliate to its parent enterprise exceed the loans and equity capital given by the parent enterprise to the foreign affiliate.[12] For example, in 2008, U.S FDI stock in Mauritania was -3 million dollars and since 2009, this has remained at zero.[13]

The analysis takes into consideration the dynamic nature of FDI. A static model specification using the fixed or random-effects and Tobit estimation may be too restrictive given that current or future investment decisions by MNEs could be affected by past FDI levels (Awokuse et al., 2012). Therefore, we employ a dynamic version of our model by including a lagged endogenous FDI as an explanatory variable. The lagged FDI value attempts to capture agglomeration effects whereby firms locate near one another in cities and industrial clusters which boosts the productivity of firms located or surrounding them. In particular, these agglomeration benefits stem from labour market pooling, input sharing, and knowledge spillovers among firms (Tao et al., 2019). We expect a positive effect of this variable. The dynamic specification for our study takes the following form:

$$FDI_{ijt} = \beta_0 + \beta_1 FDI_{ijt-1} + \beta_2 X_{ijt} + \beta_3 Z_{ijt} + \varepsilon_{ijt} \quad (3)$$

where FDI_{ijt} is the real value of bilateral FDI stock from the parent country i to the host country j respectively during year t. X_{ijt} and Z_{ijt} denote the fundamental knowledge-capital model variables and the vector of other explanatory variables respectively as defined earlier in equations (1) and (2). FDI_{ijt-1} is the lagged value of FDI; β and ε are the vectors of coefficients and the error term respectively.

[12] Available at https://www.oecd.org/daf/inv/FDI-statistics-explanatory-notes.pdf.
[13] Available on the OECD's FDI and globalisation statistics database.

The dynamic specification in Equation (3) indicates endogeneity concerns because of the presence of the lagged dependent variable as an explanatory variable (Baltagi, 2005). In order to address endogeneity concerns, we employ the generalised method of moments (GMM) technique. We present the GMM estimation proposed by Blundell and Bond (1998) estimator as opposed to the Arellano-Bond difference GMM as it has been demonstrated that adding lagged differenced variables as instruments in the level equations provide substantial efficiency gains in panels with a short time span (Blundell and Bond, 1998) and help to avoid magnifying gaps in unbalanced panel dataset (Roodman, 2009).

The robustness of the GMM estimator is assessed using two tests to check the validity of the instruments and whether the residuals are serially correlated (Arellano and Bond, 1991). First, the Hansen test of overidentifying restrictions determines the validity of the instruments. Rejection of the null hypothesis of no misspecification indicates that the model is not appropriate. Second, the Arellano-Bond test of first-order serial correlation in the error term AR(1) and no second-order serial correlation in the residuals AR(2); a rejection of AR(1) and a failure to reject AR(2) implies that the error term is not serially correlated.

The GMM analysis allows us to explore the dynamic specification of the model which may be better suited to capture the year-to-year variation in FDI. In addition, it provides an approach of instrumenting for explanatory variables that we suspect to be endogenous or predetermined (Wagner and Timmins, 2009). The OECD globalisation database sometimes reports zero values of FDI, these have been kept. Also, missing values may either be unknown or undisclosed, i.e., thus, not all countries are covered over the 28 years of the study period. This motivates the use of the forward orthogonal deviations transformation, proposed by Arellano and Bover (1995) instead of first differencing. The forward orthogonal deviations allow greater control of the instrument matrix and increase efficiency (Wintoki, et al., 2012). Since combining positive and negative values of a difference term can lead to sign reversals and implausible coefficient estimates (Blonigen et al., 2003), we use absolute values of GDP difference, skill difference, and environmental regulatory stringency difference.

Table 4 provides the empirical results from a two-step system GMM. We include year dummies in all the specifications in order to control for economy-wide shocks to outward FDI (Wagner and Timmins, 2009). In addition to the lagged value of FDI, our assumption in the GMM estimation is that all explanatory variables except distance and

year dummies are endogenous or predetermined. For example, an increase in FDI stock may increase skills in the host country as a result of expertise and training from MNEs. Thus, we treat the skill differences variable as endogenous. Also, governments may set trade and investment costs to attract foreign investors; these variables are likely to be endogenous. The two-step system GMM with collapsed instrument matrix option in choosing the optimal number of lags is carried out using xtabond2 in Stata (Roodman, 2009). Also, in order to address the issue of downward biased estimates in a two-step system GMM estimator, Windmeijer (2005) finite sample corrected standard errors are employed.

The AR(1) and AR(2) tests show no evidence for first and second-order serial autocorrelation. The Hansen test of overidentifying restrictions is under the null that all instruments are valid, higher probability value suggests that the instruments are exogenous and not correlated with the error term. The Diff-in-Hansen test of exogeneity provides p-values that are under the null that instruments used for the equations in levels are exogenous, providing evidence that these instruments are exogenous and valid.

4. Results

The empirical results are presented in this section. The results in table 4 show the effects of our explanatory variables on bilateral inward FDI to sub-Saharan Africa. The baseline estimates obtained from the fundamental KC variables are presented in column (1) of Table 4. The estimated coefficients on lagged FDI are positive and statistically significant, indicating the existence of agglomeration effects. This suggests that the effect of the previous stock of FDI creates positive externalities. These results are similar to Agiomirgianakis et al. (2003), who use the lagged value of the share of FDI in GDP, find that agglomeration economies have a positive and significant effect on attracting FDI.

Carr et al (2001) suggest that a key method of distinguishing between horizontal and vertical motivations for FDI is to analyse the relationship between countries in both market size and relative factor endowments, and FDI. According to the KC model, horizontal FDI exists if countries are similar in market size and relative factor endowments. The main variables used to identify the two different FDI motives namely horizontal and vertical are: the aggregate size, the difference in size and the difference in relative factor (skilled-labour) endowments between the parent and the host country; denoted as GDP sum, GDP difference squared and skill difference respectively in our model.

Table 4 GMM results: determinants of FDI in sub-Saharan Africa

Variables	(1)	(2)	(3)	(4)	(5)
Real FDI lagged	0.943***	0.934***	0.929***	0.937***	0.934***
	(27.89)	(32.09)	(26.17)	(28.76)	(27.55)
GDP sum	1.460***	1.483***	1.640***	1.641**	1.459*
	(2.70)	(2.97)	(2.60)	(2.47)	(1.97)
GDP difference squared	-0.042*	-0.035**	-0.041*	-0.043	-0.040
	(-1.87)	(-2.13)	(-1.84)	(-1.61)	(-1.41)
Skill difference	410.030*	355.763	615.257	440.012	374.331
	(1.76)	(1.07)	(1.48)	(1.64)	(1.31)
Skill difference*GDP difference	-0.768**	-0.831**	-0.875**	-0.925**	-0.911**
	(-2.51)	(-2.09)	(-2.20)	(-2.58)	(-2.37)
Trade costs host country	65.302**	74.758**	91.830*	54.280*	53.920**
	(2.32)	(2.05)	(1.86)	(1.68)	(2.08)
Skill difference squared*trade costs host country	-0.520	-0.367	-0.637	-0.395	-0.361
	(-1.40)	(-0.89)	(-1.20)	(-0.95)	(-0.91)
Trade costs parent country	-3.282	-7.699	-11.859	-9.723	6.189
	(-0.28)	(-0.58)	(-0.89)	(-0.77)	(0.45)
Investment costs host country	-529.048**	-726.230**	-648.385*	-534.062*	-430.692
	(-2.09)	(-2.30)	(-1.95)	(-1.85)	(-1.23)
Distance	-261.9	-320.6	-472.8	-288.4	-50.25
	(-1.64)	(-1.60)	(-1.65)	(-1.22)	(-0.21)
Natural resource endowments		157.082	238.158	103.661	89.639
		(1.44)	(1.28)	(0.86)	(0.88)
Institutional quality			230.900	336.286	166.082
			(0.91)	(0.20)	(0.12)
Financial development				-515.282	-255.753
				(-0.32)	(-0.18)
Bank efficiency				-2.170	-156.493
				(-0.00)	(-0.19)
Trade reform				1.301	1.284
				(1.15)	(1.15)
Privatisation				-263.451	-283.727
				(-0.25)	(-0.28)
Environmental regulatory stringency difference					929.208**
					(2.18)
Observations	1,916	1,916	1,916	1,916	1,916
AR (1) test (p-value)	0.200	0.199	0.199	0.201	0.201
AR (2) test (p-value)	0.255	0.258	0.262	0.260	0.262
Hansen test for overidentifying restrictions (p-value)	0.574	0.626	0.684	0.752	0.722
Diff-in-Hansen test of exogeneity (p-value)	0.507	0.533	0.641	0.756	0.915

t-statistics in parentheses. ***significant at %1, **significant at 5% and *significant at 10%.

In column (1) of Table 4, the analysis shows that the estimated coefficients on the market size variable (GDPSUM) have the expected positive effect and are statistically significant, suggesting that the larger the bilateral area of the parent and host country market size, the greater FDI. The result confirms the notion that firms tend to locate in close proximity to large markets (Faeth, 2009). This supports our hypothesis thereby providing evidence of horizontal FDI in sub-Saharan Africa.

GDP difference squared (GDPDIFFSQ) is negative and statistically significant as expected. This shows that inward FDI from an OECD parent country to a sub-Saharan Africa host country is in line with the KC model predictions of an inverted U-shaped relationship between FDI and bilateral differences in market size implying that incentives for market-seeking investment could increase as countries become more similar in size (Carr et al., 2001; Chellaraj et al., 2013). According to the knowledge-capital model, such effects of aggregate market size and the difference in market size (positive and negative respectively) are regarded as evidence for horizontal FDI.

The variable skill difference (SKILLDIFF) is positive and statistically significant, suggesting that an increase in an OECD parent country's skill compared to a sub-Saharan Africa host country in which it invests has a positive effect on FDI. The estimated coefficient in the SKILLDIFF variable captures the direct effect of skill differences on FDI, implying that the vertical component of FDI is present. However, the total effect of skill differences depends on both the direct coefficients and the interaction term coefficients. The results show that interaction term between skill difference squared and trade costs of the host country (SKILLDIFFSQ*TCH) is statistically insignificant, however, the interaction between skill difference and GDP difference (SKILLDIFF*GDPDIFF) is negative and statistically significant, confirming greater incentives for vertical FDI, given the differences in factor endowments and market size. This study finds evidence of vertical FDI in sub-Saharan Africa. This finding supports the view that MNEs investment abroad is concentrated in labour-intensive assembly activity. Our result is consistent with the KC model prediction, suggesting that FDI to the region is driven by labour-seeking incentives.

As noted earlier, the interaction between the skilled labour abundance differences and GDP differences (SKILLDIFF*GDPDIFF) has a negative and statistically significant effect on FDI. This variable is designed to capture the nonlinearities in the KC model and this result is in line with the KC model prediction, suggesting that for a given difference in skills, horizontal FDI would be smaller where market size differences are larger. This

implies that incentives for horizontal FDI diminishes compared to expanded incentives for vertical investment given large differences in skills and market size. This finding is consistent with the results in Carr et al. (2001) which suggests that vertical FDI is high if the parent country is moderately small and skill abundant compared with the host country (e.g., Sweden, the Netherlands, Switzerland).

The host country's trade costs (TCH) has a positive and statistically significant effect on FDI. This result suggests that an increase in trade costs in the host country rises FDI, thereby stimulating horizontal FDI (Carr et al., 2001). The parent country's trade costs (TCP) has a negative but insignificant effect on FDI. Also, investment costs in the host country (ICH), measured as the host country's investment costs has a negative and statistically significant effect on FDI, suggesting that higher costs of investing in a sub-Saharan Africa host country deter FDI, consistent with the results in Awokuse et al. (2012). In addition, distance (DISTANCE) has a negative but insignificant effect on FDI. Overall, the results in column (1) of table 4, provide support for the KC model. The basic KC model variables; country size and differences in factor endowments play a crucial role in foreign investment decisions.

In table 4, column (2) extends the KC model to include natural resource endowments (NRESOURCE). The result indicates that there is a positive relationship between natural resource endowments and inward FDI, however, the effect is statistically insignificant. The agglomeration effects variable (real FDI lagged), market size variable (GDPSUM) and GDP difference squared (GDPDIFFSQ) remains statistically significant, however, skill difference (SKILLDIFF) is statistically insignificant. The estimated coefficient on the interaction between skill difference and GDP difference (SKILLDIFF*GDPDIFF) remains statistically significant. The variables trade costs in the host country (TCH) and investment costs in the host (INVC) remain significant. The estimated coefficients on the interaction term between skill difference squared and trade costs of the host country (SKILLDIFFSQ*TCH) is statistically insignificant. The results suggest that the trade costs of the parent country (TCP) and distance (DISTANCE) remain insignificant.

In column (3) of Table 4, we include governance and institutional quality variable measured as the control of corruption (CORRUPT). The results show a positive but statistically insignificant relationship between the control of corruption and FDI. A possible explanation for this is that the control of corruption has not been effective because, with a

few exceptions, corruption in African countries is systemic (Gyimah-Brempong, 2002), thereby not having a positive and significant impact on FDI. It is worth noting that the introduction of this variable does not modify substantially any of the conclusions reached with columns (1) and (2).

In Table 4, column (4), we include the set of structural reform variables (SREFORMS). Following the approach implemented by Campos and Kinoshita (2010), in this specification, we examine whether financial reform (measured as financial development and bank efficiency), trade liberalisation, and privatisation of state-owned enterprises affect sub-Saharan Africa inward FDI from OECD countries.

Financial development and bank efficiency in sub-Saharan Africa have negative but statistically insignificant effects on inward FDI. These results are in contrast to those in Tang (2017), using panel data from Central and Eastern European countries, find a significant effect for financial development which is because these countries pursued deeper bank liberalisation and stock market integration. In contrast, trade reform has a positive but statistically insignificant effect on inward FDI. The effect of the privatisation of state-owned enterprises in the host country has a negative but statistically insignificant effect on inward FDI. Furthermore, the results show that coefficients on the fundamental KC variables, agglomeration effects, natural resource endowments, and institutional quality are mostly consistent with those reached in column (3), except for the GDP difference squared (GDPDIFFSQ) variable which is statistically insignificant. In sum, we do not find empirical evidence that structural reforms are important motives for FDI in sub-Saharan Africa. The lack of a significant relationship between FDI and structural reforms in the region is not surprising.

The period of our analysis for sub-Saharan Africa corresponds with the reform era when many sub-Saharan African countries adopted the structural adjustment programs (SAP) mainly based on the neoliberal "Washington Consensus". More specifically, SAP reforms were designed by the IMF and World Bank to reduce internal and external economic distortions in order to liberalise international trade and investment as well as promote private sector participation and overall to "develop" Africa. Although SAP reforms have resulted in macroeconomic and structural policy changes, they were responsible for hardships and risks to poor and developing countries, consequently, failing in promoting FDI in the region. A possible explanation for this is that sub-Saharan Africa lacked the enabling environment to support SAP reforms given that political stability, good

governance and low levels of corruption among others are prerequisites for effective SAP reforms (Skosireva and Holaday, 2010). Furthermore, the overall impact of structural reforms has been hindered by various institutional dimensions not captured in these countries. This is along the line suggested by Estrin and Pelletier (2018) who argue that structural reforms do not automatically generate the economic gains in developing countries but rather pre-conditions especially regulatory infrastructure, attention to poverty and social impacts, and the implementation of complementary policies among others are important for achieving a positive impact.

This study further investigates whether sub-Saharan African countries with relatively less stringent environmental regulation have a comparative advantage in attracting FDI, thereby turning these countries into pollution havens. Table 4, column (5) shows that the difference in environmental regulatory stringency between an OECD parent country and a sub-Saharan Africa host country has a positive and statistically significant effect on FDI. This suggests that differences in environmental regulatory stringency play an important role in attracting FDI to sub-Saharan Africa. This implies that the difference between the environmental regulatory stringency of the parent and the host country has the potential to increase inward FDI and provides the host country with a comparative advantage in attracting pollution-intensive production and industries. This paper provides evidence for the pollution haven hypothesis which posits that FDI is attracted to countries or regions with relatively less stringent environmental regulations (Kim and Adilov, 2012; Elliott and Zhou, 2013).

In order to address a number of zero FDI observations in the data sample, we consider an alternative specification and employ a Tobit estimation, which is a standard technique in the FDI literature (for e.g. Carr et al., 2001; Kalamova and Johnstone, 2011) that treats all non-positive observations as resulting from a censored procedure. Table 5 presents results from a Tobit regression. By comparing these results with the GMM estimates from Table 4, we note that for columns (1) to (5) of Table 5, the estimated coefficients on the agglomeration effects variable (Real FDI lagged), market size variable (GDPSUM), the dissimilarity variable (GDPDIFFSQ), interaction between the skill difference and GDP difference variable (SKILLDIFF*GDPDIFF), trade costs in host country (TCH) and investment costs in host country (ICH) remains consistent and have the expected effects on FDI. Other variables including the skill difference (SKILLDIFF), distance (DISTANCE), natural resource endowments (NRESOURCE), institutional quality (CORRUPT) are statistically insignificant. Furthermore, bank efficiency has a positive and

statistically significant effect on inward FDI, however financial development, trade reform and privatisation of state-owned enterprises are statistically insignificant.

Table 5 Tobit results: determinants of FDI in sub-Saharan Africa

Variables	(1)	(2)	(3)	(4)	(5)
GDP sum	9.244***	9.215***	9.218***	9.280***	9.089***
	(11.43)	(11.40)	(11.38)	(11.41)	(11.23)
GDP difference squared	-0.256***	-0.255***	-0.255***	-0.255***	-0.257***
	(-8.75)	(-8.71)	(-8.70)	(-8.68)	(-8.77)
Skill difference	-17.657	-88.561	-78.432	-158.697	-643.861
	(-0.04)	(-0.21)	(-0.17)	(-0.35)	(-1.37)
Skill difference*GDP difference	-490.9***	-489.6***	-489.8***	-495.1***	-478.4***
	(-8.06)	(-8.04)	(-8.04)	(-8.09)	(-7.85)
Trade costs host country	97.313***	101.456***	101.905***	99.826***	112.255***
	(3.05)	(3.16)	(3.10)	(3.00)	(3.37)
Skill difference*GDP difference	-354.3	-336.3	-341.6	-325.8	-373.6
	(-0.75)	(-0.71)	(-0.71)	(-0.68)	(-0.78)
Trade costs parent country	-16.553	-17.486	-17.536	-17.358	7.885
	(-0.64)	(-0.67)	(-0.67)	(-0.67)	(0.29)
Investment costs host country	-1.168**	-1.135**	-1.136**	-1.156**	-1.290***
	(-2.52)	(-2.54)	(-2.45)	(-2.49)	(-2.79)
Distance	-140.8	-89.17	-95.12	-74.86	113.3
	(-0.40)	(-0.25)	(-0.26)	(-0.20)	(0.31)
Natural resource endowments		65.954	66.758	69.310	68.727
		(1.23)	(1.21)	(1.25)	(1.25)
Institutional quality			100.982	-212.419	1.225
			(0.06)	(-0.13)	(0.72)
Financial development				1.104	1.375
				(0.82)	(1.02)
Bank efficiency				1.617	1.709*
				(1.58)	(1.67)
Trade reform				561.047	570.116
				(0.60)	(0.61)
Privatisation				-9.461	-93.754
				(-0.01)	(-0.08)
Environmental regulatory stringency difference					3.955***
					(3.66)
Observations	2489	2489	2489	2489	2489
Censored observations	2212	2212	2212	2212	2212
Log-likelihood	-39127	-39127	-39127	-39125	-39118

z-statistics in parentheses. ***significant at %1, **significant at 5% and *significant at 10%.

Further, in column (5) of Table 5, we control for the fundamental KC variables and the other FDI determinants. We find that the estimated coefficient on environmental regulatory stringency difference (ERSDIFF) remains positive and statistically significant. This points to the fact that the difference in environmental regulatory stringency of the parent and host country is a compelling factor in the production, location and investment decisions in the region. These findings confirm the pollution haven hypothesis for sub-Saharan Africa.

In summary, in order to validate the theoretical prediction of the modified KC model of multinational enterprise and identify the main reasons for undertaking FDI in sub-Saharan Africa by foreign firms from OECD countries, the use of a dynamic model and generalised method of moment (GMM) estimation in this study seems to be the most useful choice. The empirical analysis provides evidence to suggest that both horizontal and vertical investments are important to sub-Saharan Africa's economy, confirming that market access and relative factor endowments were found to be important for determining the extent of MNE activity in sub-Saharan Africa. Trade and investment costs in host countries play a major role in influencing FDI decisions. Furthermore, we also find evidence for agglomeration effects suggesting that previous stock of investment creates positive externalities. The control of corruption and structural reforms were not successful in attracting the anticipated FDI to the region during the period of review. The empirical results suggest that the difference in environmental regulatory stringency is an important FDI determinant in sub-Saharan Africa.

5. Conclusion

In this study, we propose the empirical specification of the knowledge-capital (KC) framework as described in Carr et al. (2001) for sub-Saharan Africa. Using a recently compiled panel dataset, we examine the determinants of bilateral FDI stocks between 30 OECD parent countries and 28 sub-Saharan Africa host countries over the period 1985-2012. We extend the KC model by assessing the role of natural resource endowments and institutional quality proxied as control of corruption in determining FDI to the region. We also examine the role of structural reforms, namely financial reform, trade reform and the privatisation of state-owned enterprises. We further extend the KC model by investigating whether sub-Saharan African countries with relatively less stringent environmental regulation have a comparative advantage in attracting FDI, thereby potentially turning these countries into "pollution havens". In particular, we estimated the empirical framework by

employing a two-step GMM econometric procedure that controls for unobserved heterogeneity and the endogeneity issues associated with regressing FDI with both parent and host country characteristics.

Our empirical results provide support for the KC model predictions. While explicitly accounting for the dynamic nature of international investment data, we find evidence for both horizontal and vertical FDI. The result indicates that the structure of sub-Saharan Africa bilateral inward FDI from industrialised countries is consistent with the market-seeking and lower factor cost-seeking motives for FDI. Also, our results suggest that both horizontal and vertical FDI motivations are important for sub-Saharan African economies. In addition, our study provides evidence for agglomeration effects in the region, suggesting that the location of a multinational enterprise is influenced by the location of previous multinational enterprises.

The empirical results indicate that the control of corruption is not statistically significant in determining sub-Saharan Africa inward FDI. The role of structural reforms including financial development, bank efficiency, trade reform and privatisation of state-owned enterprises has varying effects on FDI. However, overall structural reform indicators are statistically insignificant in attracting inward FDI to sub-Saharan Africa during the period. We find robust evidence of a pollution haven in the region, suggesting that differences in environmental regulatory stringency do influence sub-Saharan Africa's inward FDI. Furthermore, countries with relatively lax environmental regulations may have a comparative advantage in attracting pollution-intensive activity.

These findings provide new insights for policy issues. Given the crucial role of FDI as a catalyst for economic development, it is important to note that macroeconomic, structural and environmental policy design and implementation are vital factors in strengthening the investment climate towards attracting productive FDI. Furthermore, in view of the less stringent environmental regulation in sub-Saharan Africa, a policy recommendation from this research is that national governments and regional authorities in collaboration with the expertise from OECD countries design and implement sound environmental policy framework which is important in the economic growth and development of host countries in particular and global sustainable development in general.

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Appendix

Table 6 Definition of variables and sources

Variables	**Description and Source**
Real FDI	Foreign direct investment stocks from the parent to the host country in constant 2011 US$ (in million), using the US GDP deflator. Source: OECD International Direct Investment Statistics Yearbook
Sum of GDP, difference in GDP	The Sum/difference of gross domestic products (GDP) of the parent and the host country measured in constant 2011 US$ (in billion). Source: Penn World Tables
GDP difference squared	The squared difference of GDP between the parent and the host country in constant 2011 US$ (in billion). Source: Penn World Tables

Skill difference (squared)	Average years of schooling for the population aged 15 and over. Measured as the difference (squared) between the average educational attainment in the parent country and that of the host country. Source: Barro and Lee, 2013; Cohen and Soto, 2007 and Cohen and Leker, 2014; Penn World Tables
Investment costs host	Index from 0 to 100 of investment costs measured as 100 minus an average of several investment impediments in the host country. Source: World Economic Forum, Executive Opinion Survey
Trade costs host (parent)	Index from 0 to 100 of trade costs measured as 100 minus trade openness. Trade openness is measured as the sum of a country's exports and imports divided by the country's GDP. Source: World Development Indicators: World Bank
Distance	Distance is the distance between the capitals of the parent and the host country measured in kilometres (km). Source: Centre d'Etudes Prospectives et d'Informations Internationales (CEPII)
Natural resource endowments	Total natural resources rent as a percentage of GDP. Source: World Bank, World Development Indicators database
Institutional quality host	Rating of control of corruption in 2011 in the host country with a range of -2.5 (weak) to 2.5 (strong) governance performance. This reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption as well as "capture" of the state by elites and private interests. Source: Kaufmann et al., 2010; World Bank, Worldwide Governance Indicators
Financial development host	An index from 0 to 1 of financial development in the host country based on three underlying variables, the ratio of liquid liabilities to GDP, the ratio of private sector credit to GDP, and the ratio of commercial bank assets to the total bank assets. Source: Beck et al., 2000; World Bank' Financial Structure Dataset. Author's compilation
Bank efficiency host	An index from 0 to 1 of the efficiency of the banking sector in the host country based on the ratio of overhead costs to total bank assets and net interest margin. Source: Beck et al., 2000; World Bank' Financial Structure dataset. Author's compilation

Trade reform host	An index from 0 to 1 of trade liberalisation in the host country based on the arithmetic average of normalised average tariff rate and tariff dispersion. Source: The Heritage Foundation's Economic Freedom of the World. Author's compilation
Privatisation host	Total government's privatisation proceeds as a percentage of GDP. Source: Kikeri and Koko, 2005; World Bank privatisation database. Author's compilation
Stringency difference	Difference of the stringency levels of environmental regulation between the source and host country with a range of 1 (lax compared to other countries) to 7 (among the world's most stringent). We use the mean value over the period. Source: World Economic Forum, Executive Opinion Survey

Definition and calculation of the structural reforms' variables

Financial reforms are measured using two variables namely the overall financial development and bank efficiency.

Financial sector development consists of three variables:

a) The ratio of liquid liabilities to GDP given as currency plus demand and interest-bearing liabilities of bank and nonbank financial intermediaries
b) The ratio to GDP of credit issued to the private sector by banks and other financial intermediaries
c) The ratio of commercial bank assets to the sum of commercial bank assets and central bank assets

Also included is bank efficiency which consists of:

a) The ratio of overhead costs to total bank assets
b) Net interest margin

Trade reform or liberalisation reflects the openness of the economy to international trade. This comprises of two variables:

a) Average tariff rate
b) Tariff dispersion

We follow the procedure in Campos and Kinoshita (2010) to combine these variables into a single indicator. We normalise the variables by equating the maximum for all countries and all years (or the minimum depending on whether higher values of the

variables indicate more or less reform). We calculate the distance from each country-year data point to the global maximum (which is normalise to one) by (i) subtracting each country-year data point from the overall minimum ii) calculating the range for each series, that is, maximum minus minimum and iii) dividing the results from (i) by those from (ii).

Table 7 List of the countries included in the analysis

Parent countries:	Host countries:
Australia	Angola
Austria	Benin
Belgium	Botswana
Canada	Burkina Faso
Chile	Burundi
Denmark	Cameroon
Estonia	Cote d'Ivoire
Finland	Ethiopia
France	Gambia
Germany	Ghana
Greece	Kenya
Hungary	Lesotho
Iceland	Madagascar
Ireland	Malawi
Israel	Mali
Italy	Mauritania
Japan	Mauritius
Korea	Mozambique
Netherlands	Namibia
Norway	Nigeria
Poland	Rwanda
Portugal	South Africa
Slovak	Senegal
Slovenia	Swaziland
Spain	Tanzania
Switzerland	Uganda
Sweden	Zambia
Turkey	Zimbabwe
UK	
USA	

Chapter 2

Environmental Stringency, Structural Reforms and FDI in Sub-Saharan Africa

Abstract

This paper investigates the validity of the pollution haven hypothesis and the impact of structural reforms in sub-Saharan African countries' inward FDI while controlling for factors including return on investment, natural resource endowments and institutional quality. Agglomeration plays an important role in FDI decisions in the region. The findings suggest that environmental regulatory stringency has a significant and negative effect on patterns of sub-Saharan Africa inward FDI. This provides support for the existence of a pollution haven within the region. The study's findings suggest that infrastructure development, active private sector participation, financial and trade liberalisation are conducive to improving the investment climate in sub-Saharan Africa in order to attract productive FDI. Ultimately this is of particular interest in the pursuit of shaping and designing sound environmental policies to support sustainable development in the sub-Saharan region.

1. Introduction

The relationship between environmental regulation and foreign direct investment (FDI) has been the subject of heated debate among policymakers and environmentalists. A focal point in this debate concerns the relationship between the (relative) stringency of environmental regulation and FDI. Previous studies on the effects of environmental regulatory stringency focus on FDI inflows (outflows) to (from) a single country while using measures of environmental stringency in a given country. A fair amount of these studies is focusing on the US (e.g., List and Co, 2000; Xing and Kolstad, 2002; Eskeland and Harrison, 2003; Fredriksson et al., 2003; Cole and Elliott, 2005; Millimet and Roy, 2016), a similar analysis for sub-Saharan Africa has been neglected. This paper aims to fill this gap by providing a cross-country analysis for sub-Saharan Africa using the World Economic Forum's environmental regulatory stringency index that is commeasurable across countries. Furthermore, this study uses an alternative measure of environmental regulatory stringency and we construct the new dataset on environmental regulatory stringency based on the energy use approach for 13 sub-Saharan African countries over the period 1985-2012.[14]

The effect of host countries' environmental regulations on inward FDI patterns has, however, received relatively little attention and is the issue to which this study contributes. Of particular concern is the pollution haven hypothesis (PHH), which claims that tightening of environmental regulation in one country will lead to the (re)location of pollution-intensive production from countries with relatively stringent environmental regulations to the developing world, which generally tend to have relatively weaker environmental regulations, thus becoming "pollution havens" (Copeland and Taylor, 1994). This paper investigates the determinants of FDI in sub-Saharan Africa. Understanding the determinants of FDI is important for several reasons. First, despite significant progress achieved to date, empirical studies for sub-Saharan Africa are scarce. Second, since FDI plays a crucial role in filling the development gaps in developing countries, it is important to know the factors that attract FDI to sub-Saharan Africa. Moreover, given that FDI to sub-Saharan Africa is affected by different factors, specific policies that could promote inward FDI to the region in order to foster sustainable development remains an important aspect to policymakers in sub-Saharan Africa. In this context, effective environmental

[14] The countries in the analysis were based on data availability.

policy is important because it allows countries to attract eco-friendly FDI and further reduce environmental degradation and pollution havens.

This paper specifically attempts to shed light on the pollution haven hypothesis (PHH) and the need to control for structural reforms by constructing indexes on financial sector development, bank efficiency, trade liberalisation and privatisation of state-owned enterprises in sub-Saharan Africa. Moreover, since the stringency of environmental regulations increases with income (Dasgupta et al., 2001), this suggests that developing countries possess a comparative advantage in pollution-intensive production (Cole and Elliott, 2003). As one of the largest developing regions, sub-Saharan Africa also faces a trade-off between economic growth and environmental quality and is prone to becoming a pollution haven. As a result, sub-Saharan Africa is the perfect place to examine the PHH as we also assess other potentially important factors in explaining FDI patterns in sub-Saharan Africa, such as the level of development, return on capital, education, macroeconomic instability, infrastructure, agglomeration, natural resource endowments and institutional quality.

Although there is an extensive literature on the determinants of FDI to developing countries (Kaur and Sharma, 2013; Jiang et al., 2013; Danish and Akram, 2014; Kumari and Sharma, 2017; Khamphergvong et al., 2018), so far little empirical work has been done on the determinants of FDI in sub-Saharan Africa. This is surprising since FDI flows to the region have seen an increase in volume and importance of international investment flows over the past few years. The UNCTAD statistics indicate that total FDI into sub-Saharan Africa increased from US$248 million in 1980 to US$28.6 billion in 2017. However, in recent years sub-Saharan Africa's share of global FDI flows has declined from 2.3% in 2010 to 2% in 2017 due to decreasing return on investment and other policy risks, as perceived by foreign investors. The region's share of global inward FDI is very small considering the untapped resources and economic growth potential in sub-Saharan Africa. It is therefore important for the region to increase its share of FDI in order to fill the resource gap, which can contribute to the economic growth and sustainable development of the host country. If the region is to successfully attract FDI, it is worthwhile to explore which characteristics of sub-Saharan African countries are important determinants in attracting FDI, which is a catalyst for economic growth and sustainable development of host countries.

To gain insight into this, we explore the issue in correspondence with the "reform era" when many Sub-Saharan African countries experienced sluggish economic growth and adopted structural adjustment programs (SAP). SAP reforms were designed and governed by the IMF and World Bank to reduce internal and external economic distortions and financial imbalances which were aimed at structurally adjusting the economy to encourage private-sector investment and increase economic efficiency among others (Skosireva and Holaday, 2010).[15] Also, the need to study the impact of SAP reforms in these countries during this period are as follows: first, it would be of interest to policymakers in countries where reforms are implemented; second, to shed light on the importance of addressing inherent structural challenges in developing countries and third, structural reforms such as financial and trade liberalisation as well as private sector development acts as a strong commitment to structural changes which can be an impetus to attracting more FDI.

Sub-Saharan Africa is also of particular interest in the PHH literature because the region comprises countries with sizeable economic potential and potentially strong domestic demand that has provided support for growth through investment. Also, the economic conditions in sub-Saharan Africa have remained generally robust against the backdrop of a sluggish global economy, thereby making the region the fastest growing economy in the world (Regional Economic Outlook, 2012). Over the period 2001-2011 fast economic growth has made the region a more attractive investment destination with FDI flows into the sub-Saharan region increasing from US$14.6 billion in 2001 to US$39.2 billion in 2011 (UNCTAD, 2012).

The share of FDI in GDP has, however, not been stable over time in sub-Saharan Africa. The region witnessed growth in productive FDI in the 1980s and 1990s but slowed significantly at the start of 2000 (UNCTAD, 2012). While the share of FDI in GDP peaked in 2001, the dismal performance in recent years suggests that the huge resources and economic growth potential in sub-Saharan Africa remain unexploited. It is therefore important to understand the potential drivers of FDI in order to guide economic policy design and to facilitate the discussion on the FDI plan for sub-Saharan Africa given the crucial role of FDI as a catalyst for economic development (OECD, 2002).

It has been argued that less stringent environmental regulations in a host country affect its comparative advantage in attracting pollution-intensive production (Kim and

[15] See the Articles of Agreement and factsheets of the International Monetary Fund, available at www.imf.org/external/pp/ppindex.aspx.

Adilov, 2012). Moreover, sub-Saharan Africa is characterised by less stringent environmental regulations: in the 2011 Executive Opinion Survey conducted by the World Economic Forum (WEF), sub-Saharan African countries were reported to have less stringent environmental regulations (World Economic Forum, 2011). Despite this, no previous studies have considered whether there is a "pollution haven" in sub-Saharan Africa. Our results can be useful in explaining the macroeconomic implications of reforms and for shaping sound environmental policies and implementation which are necessary for sustainable development in countries.

To the best of our knowledge, this is the first paper that empirically analyses the effect of environmental regulatory stringency for the case of sub-Saharan Africa while assessing the role of structural reforms such as financial sector reform, trade reform and the privatisation of state-owned enterprises. In summary, this paper explores the patterns of FDI in sub-Saharan countries. The main contribution of this paper is to show that a host country's environmental regulatory stringency plays an important role in FDI decisions. The empirical analysis provides for the first time the effects of different measures of environmental regulatory stringency on inward FDI. The results show that higher environmental regulatory stringency has negative effects on inward FDI, confirming the presence of a pollution haven in sub-Saharan Africa. In addition, empirical evidence shows that structural reforms affect FDI decisions in different ways. The findings suggest that further strengthening of environmental policy, institutional and structural reforms are crucial in improving the investment conditions in host countries, thereby promoting competitiveness and productive FDI which is vital for sustainable development.

The paper is organised as follows: section 2 provides the literature review. Section 3 presents the methodology and data, section 4 discusses the results and section 5 presents the conclusion and policy implications.

2. Literature Review

FDI involves an investor acquiring substantial control and interest in a foreign enterprise or setting up a subsidiary in a foreign country (OECD, 1996). Over the past two decades, FDI inflows have rapidly increased in almost every region of the world (UNCTAD, 2012). The positive impact of FDI in both developed and developing economies has been well documented in the literature (Aitken et al., 1997; Batten and Vo, 2009; Fernandes and Paunov, 2012; Lee, 2013; Cho et al., 2017; Orlic et al., 2018). In

particular, FDI is a vital source of direct financing for developing economies, as it is known to reduce countries' current account deficit and can facilitate economic growth through stimulating transfer and spillover of technology, employment, productivity gains and the introduction of new processes and managerial skills. On the other hand, FDI may be considered as one of the major causes of environmental degradation (Omri et al., 2014).

Theoretical models of pollution havens include Pethig (1976), McGuire (1982) and Baumol and Oates (1988) who conclude that those countries that do not control pollution emissions, whilst others do, will willingly become the source of the world dirtiest industries (Baumol and Oates, 1988). The empirical evidence on whether the PHH exists in the real world is controversial and ambiguous. Foreign firms may decide to relocate or shift production to countries with less stringent environmental regulations in order to minimise production costs (Tang, 2015). Also, there is a trade-off between economic growth and environmental quality particularly in the developing countries which may result in competition to attract FDI that may lead to situations whereby these countries may lower environmental standards thereby resulting in a "race to the bottom" of environmental regulations with investments consequently migrating to these countries with lax environmental regulations (Sheldon, 2006).

Further, it has been argued that labour-intensive industries such as textiles and 'dirty' industries such as paper, petrochemical, iron and steel migrate from developed countries with stringent environmental regulations to developing countries with lax environmental regulations (Low and Yeats, 1992). Also, an increase in FDI does not necessarily increase pollution as multinationals can also export 'greener' technologies, environmental standards or more efficient production processes from developed to developing countries. This argument is known as the "pollution halo" hypothesis (Kim and Adilov, 2012).

The previous studies on the pollution haven hypothesis (PHH) may be classified into two research strands. The first strand of research examines the relationship between trade flows and environmental regulation stringency. This aspect of the literature on the PHH focuses more widely on trade flows. For example, the studies by Lucas et al., (1992); Birdsall and wheeler (1993); Akpostanci, et al. (2007) provide evidence to support the PHH. However, Janicke et al., (1997); Tobey (1990); Xu and Song (2000); find no empirical evidence that a country's environmental regulation stringency influences its trade patterns.

The second strand of research focuses on the validity of the PHH by examining FDI flows. In this approach, the relationship between environmental regulatory stringency and FDI flows is examined. The empirical results in most of the studies generally find a weak, mixed or no support for the PHH (e.g., Eskeland and Harrison 2003; Javorcik and Wei, 2004; Dean et al., 2009; Wagner and Timmins 2009). However, some previous studies that examine US FDI find evidence for the pollution haven effect (e.g., List et al., 2000; Keller and Levinson, 2002; Fredriksson et al., 2003 Cole and Elliott, 2005). In analysing the relationship between FDI and the stringency of environmental regulations, it is assumed that multinational enterprises (MNEs) seek to minimise production costs (or maximise profit) by comparing different locations to access favourably economic conditions that may affect investment decisions (Faeth, 2009). Research on the PHH has mainly been examined in different ways. While most studies examine the empirical evidence on pollution havens, some papers such as Markusen et al. (1993), Motta and Thisse (1994), Dijkstra et al. (2011) and Elliott and Zhou (2013) provide theoretical studies on the PHH. Copeland and Taylor (1994) argue that a higher income country has a strict environmental regulation, thereby specialising in relatively 'clean' goods. On the other hand, low-income countries with less stringent environmental regulations increase their specialisation in 'dirty' or pollution-intensive industries.

The previous literature that empirically examines the trade effects of pollution havens includes Van Beers and Van den Bergh (1997); Copeland and Taylor (2004); Brunnermeier and Levinson (2004); Levinson and Taylor (2008). Focusing on 'dirty' resource-based industries, Van Beers and Van den Bergh (1997) find no significant effect of environmental stringency on the exports of such goods. However, for dirty industries in non-resource-based industries, the authors find a significant negative effect. Similarly, Copeland and Taylor (2004) provide evidence in support of the PHH showing that more stringent environmental policy acts as a deterrent to trade in dirty goods exports, while Brunnermeier and Levinson (2004) find that the PHH is reflected in both international trade patterns and investment as well as actual plant location decisions. Levinson and Taylor (2008) conclude that environmental regulation has a significant impact on trade flows, thereby providing evidence for PHH.

More relevant for our study is a strand of the literature that examines FDI through the lens of capital mobility. List and Co (2000) investigate the effects of environmental regulations on FDI in the US. They find small albeit statistically significant deterrent effects of pollution abatement costs. Xing and Kolstad (2002) examine the impact of

environmental regulations on FDI of several US industries in 22 developed and developing countries. They show that the leniency of environmental regulation in a host country is a positive and significant determinant of FDI from the US for heavily polluting industries such as chemicals and metals, but an insignificant effect for less polluting industries such as electrical and non-electrical machinery, transportation equipment and food products. Keller and Levinson (2002) examine FDI in the US using differences in pollution abatement costs among US states. They find evidence that pollution abatement costs have a moderate deterrent effect on FDI. They further argue that failure to account for unobserved heterogeneity in US states can lead to an understatement of the pollution haven effect.

Examining the link between FDI and pollution in Mexico, Venezuela, Morocco and Cote d'Ivoire, Eskeland and Harrison (2003) find weak evidence in support of the PHH. More specifically, their result suggests that foreign investors are concentrated in sectors with high levels of air pollution. They also find no evidence that FDI in the aforementioned countries is related to abatement costs in developed countries. The authors argue that foreign firms are more energy-efficient and tend to use cleaner energy. The latter result reflects empirical support for the pollution halo hypothesis that multinational companies export advanced pollution abatement technology to developing countries. Cole and Elliott (2005) show that the US outward FDI flows to Brazil and Mexico across industries in the manufacturing sector vary positively with pollution abatement cost, finding some evidence of pollution haven consistent behaviour. Tang (2015) found a negative effect of local environmental regulations on inward FDI using US outward FDI data for 50 host countries. They further argue that FDI in the host country is not only affected by own environmental regulation but also by environmental regulations in neighbouring countries. Similarly, Millimet and Roy (2016) using US-state level data show that their own environmental regulation negatively impacts inward FDI.

Taking a look at the PHH in Europe and China, using firm-level data on investment projects in Central and Eastern Europe and in the former Soviet Union, Javorcik and Wei (2004) analyse the determinants of actual and planned investment by 534 major multinational firms. They find no robust evidence for the PHH. Also, their results suggest that higher corruption in host countries with weak environmental regulations may deter FDI. Wagner and Timmins (2009) examine the effects of environmental regulatory stringency on outward FDI flows of various industries in the German manufacturing sector

in 163 destination countries. They find evidence which is consistent with the pollution haven effect that more stringent environmental regulation deterred foreign direct investment in the chemical industry after controlling for agglomeration effects and unobserved heterogeneity. Using a similar measure of environmental stringency, Kalamova and Johnstone (2011) analyse the PHH among 27 OECD source countries and 99 developed and developing (host) countries. They find that relatively lax environmental regulation in the host country has a significant positive effect on FDI flows. They further argue that when the environmental regulation of a developing host country becomes too lax, the country loses its attractiveness as a potential FDI location, which is consistent with the PHH. Mulatu (2017) uses data on UK-based multinational activity in 64 countries and 23 industries over the period 2002-2006 to provide evidence of a significant effect of environmental regulation on the pattern of UK outbound FDI.

Using provincial data for China, Zhang and Fu (2008) found that FDI prefers to locate in regions with relatively weak environmental regulations, thereby providing some support for the existence of a pollution haven in China. In another study, Dean et al., (2009) examined whether foreign investors are attracted to weak environmental regulation in China. Their results provided mixed findings: investment in highly polluting industries funded through Hong Kong, Macao and Taiwan were attracted by weak environmental regulations, but investment from developed countries to China was not. More recently, Cai et al. (2016) investigated whether environmental regulation affects China's inbound FDI. They provide evidence in support of the PHH, suggesting that MNEs from countries with more stringent environmental regulations than China are insensitive to the toughening environmental regulation, while those from countries with relatively less stringent environmental regulations than China show strong deterrent effects. Using firm-level data of manufacturing firms in the Jiangsu Province of China, Yang et al. (2018) assessed the impact of environmental regulations on FDI location decisions. They provide mixed evidence, suggesting that different measures of environmental regulations lead to different conclusions of the PHH.

Within the body of the empirical literature, to the best of our knowledge, no study has focused exclusively on sub-Saharan Africa when investigating the effect of environmental regulatory stringency on inward FDI and the role of structural reforms while controlling for other important determinants of FDI. Among the empirical studies on the determinants of FDI are Morisset (2000), Asiedu (2002), Okafor et al. (2015) and Cleeve et al. (2015). These papers argued that structural reforms are important determinants of

inward FDI. However, these do not include and explore the impact of environmental stringency on FDI, which is the focal point of this paper. This study contributes to the above literature by using a newly compiled dataset on measures of environmental stringency and structural reforms, which allows us to comprehensively analyse the determinants of FDI and, correspondingly, the PHH in sub-Saharan Africa.

In summary, the previous literature suggests that the empirical results are inconclusive. Possible reasons are the difficulties in finding exogenous measures of environmental regulatory stringency and a number of data and methodological problems that are often related to unobserved heterogeneity. For example, Xing and Kolstad (2002) use SO_2 emissions as a measure of regulatory stringency. The use of such latent measures requires making assumptions on the underlying relationship between unobserved environmental stringency and pollution levels (see Brunel and Levinson, 2016). In this paper, we address these issues by applying two measures of environmental regulation stringency namely the World Economic Forum and the energy use indicators. Let us next turn to a more detailed discussion of the method and data.

3. Methodology and Data

In this section, we empirically assess the determinants of FDI for sub-Saharan African countries. We follow the existing literature on cross-country FDI patterns and investigate the relationship between FDI and environmental regulation in sub-Saharan Africa using pooled ordinary least squares (OLS) and random-effects generalised least square (GLS). To test the robustness of our empirical results, we will be applying the feasible generalised least square (FGLS) estimator following Agiomirgianakis, et al. (2003). Using an array of control variables, we include the first lagged share of FDI to address potential endogeneity problems associated with modelling foreign investment and also include first lagged values of all explanatory variables given that FDI decisions may be made based on historical data. The use of the FGLS technique is to further control for unobserved heterogeneity and cross-sectional correlation as well as heteroscedasticity (Zhang and Fu, 2008). We construct a panel dataset that includes 13 sub-Saharan African countries covering the period 1985-2012. The countries included in the analysis are Angola, Botswana, Cameroon, Cote d'Ivoire, Ghana, Kenya, Mozambique, Namibia, Nigeria, Senegal, South Africa, Tanzania and Zambia. These countries were selected based on data availability. To analyse the effect of the host country's environmental regulatory stringency on inward FDI, we consider all thirteen countries in sub-Saharan Africa in which data for

our two measures of environmental regulatory stringency is available. Countries excluded due to lack of data availability include South Sudan, Rwanda, Guinea Bissau, and Eritrea.

The general form of the investment model to be estimated is given by:

$$(FDI/GDP)_{it} = \alpha_i + \beta_1 ERS_{it} + \beta_2 X_{it} + \varepsilon_{it} \quad (1)$$

where $(FDI/GDP)_{it}$ denotes real FDI and is the share of FDI stock to GDP in country *i* at time *t*, it is the dependent variable. We employ real FDI values to adjust for inflation. Environmental stringency, the primary variable of interest, is reflected by ERS in country *i* in year *t*, while X is the vector of control variables that may affect FDI; β and ε are the vector of coefficients to be estimated and the error terms, respectively. We define the dependent variable as the stock of FDI in the sub-Saharan African country expressed as a percentage of GDP. Since we are interested in the level of activity of MNEs, we use FDI stocks rather than flows because stocks are a close proxy of multilateral activity than flows (Kahouli and Maktouf, 2015). Braconier et al. (2005) suggest that using FDI stocks rather than flows may actually be an advantage, for stocks are long term decisions to invest and are less volatile, and less dependent on missing variables. FDI data was obtained from the UNCTAD database while real GDP data are from the Penn World Tables.

We estimate Equation (1) for two separate measures of environmental stringency. The first measure is taken from the Executive Opinion Survey conducted by the World Economic Forum (WEF). The WEF stringency measure is employed in a number of studies discussed above, such as Wagner and Timmins (2009), Johnstone and Kalamova (2011), Johnstone et al (2012), Tang (2015) and Mulatu (2017). In the survey, individuals (the respondents) who routinely assess and make investment decisions, are requested to indicate the stringency of their country's overall environmental regulation. The response to this is on a Likert scale of 1 to 7, where 1 is lax compared with that of most other countries and 7 is among the world's most stringent. For example, the WEF index in 2012 reported that developed countries including Germany and Finland both had a score of 6.4, compared to other developed economies, e.g. US (5.4), UK (5.5), Japan (5.9) and France (5.1) while least developed countries including Yemen and Haiti had 2 and 1.5 respectively. In our sample, this variable ranges from 2.1 (Cote d'Ivoire) as the lowest to 4.5 (South Africa) as the highest value (World Economic Forum, 2011). Due to data availability, this paper uses the mean values of this indicator.

Table 8 Measures of environmental regulatory stringency in sub-Saharan African countries

	WEF survey	**Energy intensity**
Cote d'Ivoire	2.1	0
Angola	2.9	1
Cameroon	3	0
Mozambique	3.2	1
Nigeria	3.2	0
Senegal	3.2	0
Zambia	3.3	0
Ghana	3.4	1
Tanzania	3.7	1
Kenya	3.8	0
Botswana	3.9	1
Namibia	4.4	1
South Africa	4.5	1

Source: 2011 World Economic Forum (WEF) Global Competitive Executive Opinion Survey of environmental regulatory stringency by CEOs; Energy intensity computation using data from the International Energy Agency (2014).

In addition to the WEF stringency measure, we also employ an alternative measure of stringency of environmental regulation. Brunel and Levinson (2016) provide an excellent review of the various measurement approaches that researchers have used to measure the stringency of environmental regulations. They grouped the approaches into five categories, namely private sector abatement costs, direct assessments of individual regulations, composite indexes, measures based on pollution and energy use, and measures based on public sector expenditures or enforcement. Cole and Elliott (2003) apply the energy use approach to environmental regulatory stringency, which is based on a country's change in energy intensity (energy consumption/GDP) and the level of energy intensity. The index is from 0 (low regulations) to 1 (high regulations). All things being equal, high energy intensity is associated with relatively lenient stringency. The hypothesis is that the laxer the environmental regulatory regime is, the greater the comparative advantage in their competition for FDI. The source of this data is the International Energy Agency (IEA) energy statistics database. The construction of the energy use index as a proxy for environmental stringency is described in the Appendix.

The index in our sample varies across countries and is based on the country's energy efficiency. For example, in Table 8, a low-income country such as Mozambique has an index of 1 while a middle-income country such as Nigeria has an index of 0. Given the focus that energy is a polluting input (van Soest et al., 2006), this paper will follow Cole

and Elliott (2003) and apply the energy use index as the consistent proxy of environmental regulatory stringency. However, the index has few weaknesses, namely the challenge to fully capture the multidimensionality of policy regulations, and the difficulty to determine whether the measure of environmental stringency is largely the result of changes in energy use or levels of energy use. Both changes and levels could be due to energy prices, industrial composition, and trade liberalisation. Furthermore, if environmental regulations drive up energy prices, energy expenditures may not decrease as a share of GDP even if energy use has also decreased (Brunel and Levinson, 2016; Hille, 2018).

The vector of control variables X_{it} includes traditional FDI determinants, structural reforms, and institutional factors. The traditional FDI determinants commonly used in the literature and which are used here are GDP to reflect development, human capital, inflation rate, return on investment, infrastructure, agglomeration effects and natural resource abundance (Elheddad, 2018). We use real GDP growth to account for the level of development in the host country. All else being equal, it is expected that countries with a higher GDP growth attract more investment. Human capital is measured as the ratio of total enrolment in secondary education of the active population aged 15-65. This reflects the level of education of workers in the host country and is expected to be positively related to FDI. We also include the host country inflation rate which reflects economic stability. Krugell (2005) argues that a high inflation rate signals internal economic pressure and the inability of the government and the central bank to balance the budget and restrict the money supply. This increases investment risks and the costs of doing business. Consequently, a high inflation rate is expected to have a negative impact on FDI. Data on this variable and secondary school enrolment ratio are from the World Bank's Development Indicators databases.

It is argued that multinationals seek to maximise profit and that FDI is expected to go to countries that pay a higher return on capital (Asiedu, 2002; Zhang and Fu, 2008). Asiedu (2002) argues that this variable is difficult to measure which may be due to a lack of well-functioning capital markets in most developing countries, thereby making testing the hypothesis difficult. Following this literature, the inverse of real per capita GDP is used to measure the return on capital in this study. Furthermore, given the assumption that the marginal product of capital is equal to the return on capital, capital-scarce countries with lower real GDP per capita would yield a higher return on investment based on the assumption that the marginal product of capital is equal to the return on capital. It is

expected that the higher the return, the greater the level of inward FDI. In particular, the hypothesis is that the development of infrastructures such as transportation and telecommunication attract FDI. Following the common literature (Asiedu, 2002; Anyanwu, 2012; Krugell, 2005), we include infrastructure development and the number of telephone lines per 1000 population. The use of the availability of telephone lines is because they are necessary conditions for foreign investors to operate successfully and they facilitate communication between the parent and host countries (Anyanwu, 2012).

Following Agiomirgianakis et al. (2003) and Wagner and Timmins (2009), we further include agglomeration effects as another potential explanatory factor attracting FDI in the host country. In this respect, the lagged share of FDI is a measure of agglomeration effects to capture the presence of previous MNEs' activity in the host country, and which is expected to have a positive effect on FDI. In the same vein, the total of natural resources rents (as a percentage of GDP) is often used as a measure of natural resource endowments (Cleeve et al., 2015), where it is hypothesized that countries with abundant natural resources attract FDI (Rodriguez-Pose and Cols, 2017). This variable and the infrastructure variable were obtained from the World Development Indicators compiled by the World Bank.

In recent years, many sub-Saharan African countries have witnessed increased macroeconomic instability, where structural reforms were implemented, aimed at reducing domestic (and external) economic distortions and financial imbalances (Skosireva and Holaday, 2010). In the spirit of Campos and Kinoshita (2010), we consider the most important reforms that may attract FDI to a host country and confine structural reforms as a combination of indicators such as financial sector liberalisation, reduction in trade barriers, and the privatisation of state-owned enterprises. The hypothesis is that financial and trade liberalisation, as well as privatisation, stimulates FDI, ceteris paribus (Asiedu, 2002; Boubakri et al., 2009; Campos and Kinoshita, 2010; Rjoub et al., 2017). We include two measures to reflect financial liberalisation in the region: financial development which captures the depth of financial markets and bank efficiency which indicates the efficiency of the banking sector. Financial sector development is measured based on three underlying variables: the ratio of liquid liabilities to GDP, the ratio to GDP of credit issued to the private sector by banks and other financial intermediaries and the ratio of commercial bank assets to the sum of commercial bank assets and central bank assets. Bank efficiency is based on the ratio of overhead costs to total bank assets, and net interest margin. The source

of the financial reform variable is the June 2016 version of the World Bank' Financial Structure dataset (Beck et al., 2000).

Although trade openness is commonly used in studies of trade liberalisation, however, in this paper, the trade reform variable reflects trade liberalisation and is measured as a combination of the average tariff rate and tariff dispersion. In so doing we are able to differentiate reform efforts from reform outcomes. For instance, improvements in trade openness may be a result of other factors such as exchange rate regime, climate shocks, technological change or fluctuations in the trade policy of major trading partners.[16] The variable, tariff rate, is designed to measure restraints affecting international trade and to capture a country's tariff policy. For example, in 2016 countries like Cote d'Ivoire and Ghana have a uniform tariff structure with an average tariff of 7.56 percent and a tariff dispersion of 7.02. On the other hand, countries can have different tariff structures. For example, Tanzania and Swaziland have an average tariff of 7.42 and 8.48 percent respectively, with a standard deviation of 5.10 and 5.56 respectively. The average tariff is calculated as the mean applied ad-valorem duty across tariff lines and the tariff dispersion is the standard deviation of tariffs around their mean values. We normalise these variables by subtracting the actual value from the minimum in the numerator so that the larger value indicating more trade reform efforts. We then took the mean values of the average tariff rate and the tariff dispersion to obtain the trade reform index. The index is measured on a scale of 0 to 1. These variables were obtained from the Heritage Foundation's Economic Freedom of the World (Gwartney et al., 2000). Summary statistics are presented in Table 9. Definitions and sources of variables used are given in the Appendix.

The privatisation variable is designed to capture the notion of state-owned enterprises, which is measured as all privatisation proceeds in countries measured in millions of US Dollars (Kikeri and Kolo, 2005). By using this indicator, we capture the government privatisation efforts. Privatisation proceeds are defined as all government revenues from privatisation resulting from partial and full divestitures through the sale of shares or asset sales, concessions, leases, and other arrangements. However, this excludes management contracts, green-field investments, and investments made by new private operators as part of concession agreements as well as all those transactions with a foreign buyer. The privatisation variable is measured as the total privatisation proceed as a percent of GDP.

[16] Campos and Kinoshita (2010) also make this important point.

Table 9 Summary statistics

Variables	Mean	Standard deviation	Minimum	Maximum	N
FDI/GDP (% of GDP)	0.089	0.085	0.001	0.556	364
GDP growth (% rate)	4.724	10.923	-23.98	201	364
Human capital (% rate)	33.529	22.741	3.412	94.863	364
Inflation (% rate)	45.469	272.753	-4.141	4145.108	364
Return on investment (1/GDP per capita)	475.949	523.018	71.3	3190.798	364
Infrastructure (phones per 1000 people)	488.036	1127.115	10.576	5492.838	364
Natural resource endowments (% rate)	11.373	12.546	0.374	63.55	361
Institutional quality (-2.5-2.5)	-0.485	0.638	-1.337	0.979	364
Financial development (0-1)	0.448	0.259	0	1	364
Bank efficiency (0-1)	0.463	0.312	0	1	364
Trade reform (0-1)	0.558	0.302	0	1	364
Privatisation (% of GDP)	0.0001	0.001	0	0.008	364
Environmental stringency (WEF), (1-7)	3.431	0.617	2.1	4.5	364
Environmental stringency (Energy use), (0-1)	0.539	0.499	0	1	364

The source of this data is the World Bank privatisation database. It is expected that overall structural reforms should have positive effects on inward FDI. A detailed definition, sources and construction of the structural reform variables are provided in the Appendix. The correlation matrix of all variables used in the analysis is presented in Table 10.

Table 10 Correlation matrix

Variables	FDI/GDP	Environmental stringency		GDP growth	ROI	HC	Inflation	Infrastructure	NRE	INQ	FD	BE	TR	PS
		WEF	Energy use											
FDI/GDP	1.000													
Environmental stringency (WEF)	0.193	1.000												
Environmental stringency (energy use)	0.270	0.496	1.000											
GDP growth	0.044	0.101	0.112	1.000										
Return on investment (ROI)	-0.129	-0.236	0.030	-0.018	1.000									
Human capital (HC)	0.188	0.672	0.251	0.042	-0.370	1.000								
Inflation	-0.045	-0.097	0.103	0.013	-0.023	-0.132	1.000							
Infrastructure	0.067	0.467	0.198	0.059	-0.195	0.616	-0.051	1.000						
Natural resource endowments (NRE)	0.163	-0.284	0.036	0.026	-0.031	-0.318	0.333	-0.098	1.000					
Institutional quality (INQ)	0.224	0.654	0.552	0.081	-0.099	0.596	-0.151	0.170	-0.478	1.000				
Financial development (FD)	0.250	0.190	0.164	0.021	-0.070	0.323	-0.146	0.148	-0.158	0.183	1.000			
Bank efficiency (BE)	-0.031	-0.036	-0.201	-0.050	-0.093	-0.214	-0.033	-0.223	0.095	-0.000	-0.164	1.000		
Trade reform (TR)	0.266	0.170	0.109	0.054	-0.345	0.346	-0.039	0.136	-0.129	0.246	0.371	-0.277	1.000	
Privatisation (PS)	-0.004	-0.069	0.028	0.042	0.314	-0.189	-0.012	-0.086	-0.027	-0.020	-0.100	-0.045	-0.157	1.000

The relationship between institutions and FDI in sub-Saharan Africa is also incorporated into the model specification, in particular, institutional quality in sub-Saharan Africa host countries. The hypothesis is that institutional quality in the host country stimulates the attraction of FDI, ceteris paribus. The institutional quality variable reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption as well as 'capture' of the state by elites and private interests (Kaufmann et al., 2010). The ratings range from -2.5 to 2.5, a high rating implies a strong governance performance. In table 11 we present the institutional quality variable measured as control of corruption. In our sample, this variable ranges from -1.30 (Angola) as the lowest compared with that of most countries, for example, Somalia (-1.59) and Burundi (-1.44), to 0.92 (Botswana) as the highest value compared with that of world's efficient institutions, for example, Denmark (2.39) and Singapore (2,15) These variables were drawn from the Worldwide Governance Indicator (2012) compiled by the World Bank.

Table 11 Institutional quality in sub-Saharan African countries

	Institutional quality
Angola	-1.30
Cameroon	-1.27
Nigeria	-1.15
Kenya	-1.09
Cote d'Ivoire	-0.86
Tanzania	-0.80
Mozambique	-0.58
Zambia	-0.36
Senegal	-0.29
South Africa	-0.17
Ghana	0.1
Namibia	0.29
Botswana	0.92

Source: 2012 Worldwide Governance Indicators (WGI) from the World Bank database.

In order to address endogeneity concerns associated with FDI and the various explanatory variables, we measure the vector of the explanatory variables prior to the investment decision (Agiomirgianakis et al., 2003). Moreover, this variable also denotes the presence of agglomeration effects, that is, the benefits firms derived by locating near one another in cities and industrial clusters (Tao et al., 2019). The amended model

specification for our baseline Equation (1) then includes the lagged value of FDI (as a percentage of GDP) and becomes:

$$(FDI/GDP)_{it} = \alpha_i + \beta_1 ERS_{it-1} + \beta_2 FDI_{it-1} + \beta_3 X_{it-1} + \varepsilon_{it} \quad (2)$$

We estimate equation (2) using different techniques to strengthen our empirical results. First, we employ pooled ordinary least squares (OLS). The results are presented in Table 12. Second, since our panel dataset has both time-variant and time-invariant explanatory variables, the use of a fixed-effects model is not feasible, thus we perform a random-effects generalised least squares (GLS) estimation. This method uses the estimated autocorrelation coefficient to transform the observations and then divides the transformed equation by the standard error of the residuals, to remove autocorrelation and heteroskedasticity respectively (Cole et al., 1997). Both conditions were found to exist when the residuals from ordinary least squares estimations were analysed. Note that the Breusch-Pagan test is used to test for heteroskedasticity, while the Wooldridge test is used to test for autocorrelation. Moreover, we take account of the fact that FDI decisions may be made on previous data and hence the set of explanatory variables is measured prior to the investment decision using one period lagged values and estimated using GLS. This approach addresses the problem of endogeneity when examining macroeconomic flows (Baltagi, 1995). The results are presented in Table 13. Finally, for further robustness check, we employ the feasible generalised least square estimator (FGLS), following Agiomirgianakis et al., (2003). The results are reported in Table 14. The benefits of using this approach are that (i) it allows a model with cross-sectional correlation and heteroscedasticity and (ii) it produces consistent estimates while relaxing the assumption of no autocorrelation within panels (Zhang and Fu, 2008).

4. Results

One of the focal points of this paper is to specifically investigate the effect of environmental regulatory stringency on FDI, but at the same time controlling for the role of structural reforms, institutional factors and other FDI determinants. This section presents the empirical results for our estimation of Equation (2). Table 12 shows the results using pooled ordinary least squares (OLS). Columns (1)-(2) are results from the World Economic Forum (WEF) environmental regulatory stringency index. Columns (3)-(4) are results from the energy use environmental regulatory stringency index.

Table 12 OLS results: determinants of FDI in sub-Saharan Africa

	WEF stringency		Energy use stringency	
Variables	(1)	(2)	(3)	(4)
Environmental regulatory stringency	-0.344***	-0.307***	-0.198***	-0.177***
	(-11.49)	(-10.33)	(-11.49)	(-10.33)
GDP growth	0.002	0.003	0.002	0.003
	(0.07)	(0.12)	(0.07)	(0.12)
Returns on investment	-101.6***	-90.22***	-101.6***	-90.22***
	(-8.15)	(-7.24)	(-8.15)	(-7.24)
Human capital	-0.002***	-0.002***	-0.002***	-0.002***
	(-4.44)	(-3.78)	(-4.44)	(-3.78)
Inflation	-0.004***	-0.003***	-0.004***	-0.003***
	(-3.69)	(-3.35)	(-3.69)	(3.35)
Infrastructure	0.005***	0.004***	0.005***	0.004***
	(4.54)	(4.18)	(4.54)	(4.18)
Natural resource endowments	0.003***	0.002***	0.00253***	0.002***
	(5.83)	(5.12)	(5.83)	(5.12)
Institutional quality	0.306***	0.255***	-0.081***	-0.090***
	(12.12)	(9.71)	(-3.01)	(-3.47)
Financial development		-0.049***		-0.049***
		(-3.76)		(-3.76)
Bank efficiency		0.050***		0.050***
		(4.96)		(4.96)
Trade reform		0.003		0.003
		(0.27)		(0.27)
Privatisation		1.460		1.460
		(0.55)		(0.55)
Observations	361	361	361	361
R^2	0.755	0.779	0.755	0.779

t-statistics in parentheses. ***significant at %1, **significant at 5% and *significant at 10%.

The results reported in column (1) of Table 12 indicate that the key variable – environmental regulatory stringency – has a significant negative relationship with inward FDI to sub-Saharan Africa. Thus, higher environmental regulations in sub-Saharan African countries deter inward FDI. This is consistent with the pollution haven hypothesis, and it implies that multinational firms prefer to locate their production of pollution-intensive industries in countries with less stringent environmental regulations.

The growth rate of real GDP is positive but not statistically significant in explaining inward FDI to the region. Return on investment, human capital and inflation are robustly negative and statistically significant. This suggests that sub-Saharan African countries with a higher return on investment, human capital development and higher inflation rate do not attract more FDI. One possible explanation is that sub-Saharan Africa is perceived by foreign investors as being innately risky. The infrastructure development indicator, natural

resource endowments and control of corruption are robustly positive and statistically significant. It is consistent with the FDI theory that infrastructure, natural resource endowments and institutional quality, for example, the control of corruption, are important factors for attracting productive inward FDI.

The results in column (2) of Table 12 confirm the effects of environmental regulatory stringency, the growth rate of real GDP, return on investment, human capital, inflation, infrastructure development, natural resource endowments and control of corruption on inward FDI to sub-Saharan Africa. We include our structural reform indicators and test whether countries in sub-Saharan Africa receive more FDI as a result of financial and trade reforms, and privatisation of state-owned enterprises. Financial development has a negative and statistically significant effect on inward FDI. This suggests that greater financial development in sub-Saharan African countries leads to less inward FDI, similar to the results of Anyanwu (2012). The coefficient on bank efficiency is positive and statistically significant. This finding demonstrates the importance of the host country's efficient banking sector and that well-developed domestic financial markets are a necessary condition for attracting FDI, similar to the results of Campos and Kinoshita (2010). The trade reform and privatisation of state-owned enterprises coefficients are positive but not statistically significant.

The alternative measure of environmental regulatory stringency based on energy use is reported in Columns (3) to (4) in Table 12. Consistent with our earlier results, environmental regulatory stringency has a negative and statistically significant effect on inward FDI, implying that higher environmental regulations decrease inward FDI. The estimated coefficients on the growth rate of real GDP, return on investment, human capital, inflation, infrastructure development, natural resource endowments, financial development, bank efficiency, trade reform and privatisation of state-owned enterprises remains consistent with our earlier results. However, the only unexpected result is that the coefficient of institutional quality proxied as control of corruption variable is negative and statistically significant. The reason could be because sub-Saharan African governments and institutions have not been able to balance energy use with economic growth which leads to economic inefficiency and subsequently have an adverse effect on inward FDI. This means that the quality of institutions and governance matters for FDI decision making in sub-Saharan Africa.

Given that the FDI decision is made based on previous data, we provide an analysis in which all the explanatory variables are lagged by one period (Anyanwu, 2010). This

approach allows us to address the problem of endogeneity when examining macroeconomic flows (Baltagi, 1995). Also, the lagged share of FDI is introduced to take account of the existence of agglomeration economies. Further, the implication of this variable is not only to capture agglomeration effects but also to signal the absorbing capacity of the host country (Agiomirgianakis et al., 2003). Table 13 shows the results when Equation (2) is estimated using one period lagged variables and with random-effects generalised least squares (GLS) to control for autocorrelation and heteroskedasticity. Columns (1) to (2) shows the results when we employ the World Economic Forum environmental regulatory stringency measure. In columns (3) to (4), we provide an alternative measure from the energy use proxy as an environmental regulatory stringency indicator.

The empirical findings in Table 13 show the relationship between FDI and the stringency of environmental regulation while controlling for previous values of FDI and one-period lagged values of all explanatory variables using random-effects generalised least squares (GLS) technique. Columns (1) to (2) shows the results using the World Economic Forum environmental regulatory stringency indicator. Columns (3) to (4) show the results from the energy use proxy for environmental regulatory stringency. The results from columns (1) to (4) show that the estimated coefficient on the lagged value of FDI (as a share of GDP) is statistically significant and positively associated with FDI. We find evidence that the presence of existing foreign firms in a particular location tends to attract new foreign firms. This implies the presence of agglomeration economies given that foreign investors are attracted to countries with more existing foreign investment. Furthermore, in conditions when foreign investors do not have adequate knowledge of a host country's environment, they may resort to the investment decisions of others as a good signal of favourable conditions and invest there too, in order to reduce uncertainty (Anyanwu, 2012). The result indicates that there is a localisation advantage derived by MNEs clustering in locations thereby playing a major role in foreign investment decisions. This provides support for agglomeration effects suggesting that previous stock of investment creates positive externalities that attract FDI to sub-Saharan African countries. This result is in line with Agiomirgianakis et al. (2003) and Wagner and Timmins (2009), who find that agglomeration has a positive and significant effect on FDI.

Table 13 Random-effects GLS results using lagged explanatory variables

	WEF stringency		Energy use stringency	
Variables	(1)	(2)	(3)	(4)
Environmental regulatory stringency	-0.051**	-0.045*	-0.030**	-0.026*
	(-2.24)	(-1.94)	(-2.24)	(-1.94)
FDI/GDP	0.857***	0.846***	0.857***	0.846***
	(22.62)	(21.10)	(22.62)	(21.10)
GDP growth	-0.005	-0.005	-0.005	-0.005
	(-0.38)	(-0.35)	(-0.38)	(-0.35)
Return on investment	-35.48***	-33.26***	-35.48***	-33.26***
	(-4.18)	(-3.84)	(-4.18)	(-3.84)
Human capital	0.002	0.003	0.002	0.003
	(0.76)	(0.93)	(0.76)	(0.93)
Inflation	-0.005	-0.005	-0.005	-0.005
	(-0.72)	(-0.87)	(-0.72)	(-0.87)
Infrastructure	0.006	0.005	0.006	0.005
	(0.91)	(0.73)	(0.91)	(0.73)
Natural resource endowments	0.005*	0.005*	0.005*	0.005*
	(1.83)	(1.87)	(1.83)	(1.87)
Institutional quality	0.051***	0.044**	-0.007	-0.006
	(2.59)	(2.23)	(-0.42)	(-0.34)
Financial development		-0.012		-0.012
		(-1.40)		(-1.40)
Bank efficiency		0.006		0.006
		(0.94)		(0.94)
Trade reform		0.012*		0.012*
		(1.66)		(1.66)
Privatisation		-2.335		-2.335
		(-1.37)		(-1.37)
Observations	348	348	348	348
R^2	0.908	0.910	0.908	0.910
Wald χ^2	2984.13	3019.50	2984.13	3019.50

z-statistics in parentheses. ***significant at %1, **significant at 5% and *significant at 10%.

Column (1) of Table 13 controls for the sub-Saharan African host countries' environmental regulatory stringency in addition to GDP growth rate, the expected return on investment, human capital, inflation rate, infrastructure, natural resource endowments and institutional quality. The estimated coefficient on the environmental regulatory stringency indicator is negative and statistically significant while controlling for other factors that may influence the pattern of FDI given that environmental regulation alone cannot adequately explain FDI decisions in sub-Saharan Africa, which indicates that an increase in environmental regulatory stringency leads to a decrease in inward FDI. This result supports the PHH which suggests that the tightening of environmental regulation in one country will lead to the location or relocation of pollution-intensive production from

countries with stringent environmental regulations to countries with less stringent environmental regimes, for example, the developing countries which are generally considered to have weaker environmental regulations, thereby becoming pollution havens.

The growth rate of GDP, which captures the notion of the level of development, has a negative but statistically insignificant impact on FDI in sub-Saharan Africa. The return on investment, measured as the inverse of GDP per capita, has a negative and significant effect on inward FDI. Human capital, measured as the rate of secondary school enrolment, has a positive but insignificant effect on FDI. Inflation in the host country is negatively related to FDI, albeit is statistically insignificant. Infrastructure development measured as telephone availability is positive but not statistically significant in attracting inward FDI to sub-Saharan Africa.

Further, natural resource endowments have been historically known to be an important driver of inward FDI to sub-Saharan Africa (Cleeve et al., 2015). Controlling for this generates a positive and statistically significant relationship between natural resource endowments and inward FDI. This finding provides evidence in support of the existence of natural resource-seeking FDI in sub-Saharan Africa. The quality of institutions affects both the costs of investment and the risk premium that the parent companies demand on their investments (Wagner and Timmins, 2009). In this respect, the result for institutional quality shows a positive and statistically significant effect on FDI in the sub-Saharan region. The institutional quality has been strengthened in this region in recent years through assistance from the international communities, thereby indicating the importance of institutions in attracting inward FDI in the long run (Rodriguez-Pose and Cols, 2017). The result suggests that institutions and governance matter in FDI decisions in sub-Saharan Africa. Several studies (e.g., Alfaro et al., 2004; Prati et al., 2012) have highlighted the role of structural reforms in FDI. Following the approach implemented by Campos and Kinoshita (2010), we empirically examine whether structural reforms in the region such as financial reform variables measured as financial development and bank efficiency, trade reform which reflects trade liberalisation, and increased private-sector participation measured as privatisation of state-owned enterprises, affect sub-Saharan Africa inward FDI.

Column (2) of Table 13 includes our structural reform variables. The results show a negative but statistically insignificant relationship between financial development and inward FDI to sub-Saharan Africa, indicating that MNEs are less responsive to the financial

development in the region during the period of study. The negative effect of financial development on FDI is in line with findings from Khan and Hye (2014) for Pakistan, however this negates the findings by a number of studies, for instance, Alfaro et al. (2004) for Latin America, Khan (2011) for Pakistan, Campos and Kinoshita (2012) for Eastern Europe and Latin America. In contrast, bank efficiency has a positive effect on FDI though this is statistically insignificant. Trade liberalisation has a positive and statistically significant effect, suggesting that policies aimed at reducing international trade barriers were found to play a key role in influencing inward FDI to the region. This result is similar to the finding of Campos and Kinoshita (2010) for Latin America.

In addition, privatisation of state-owned enterprises has a negative but statistically insignificant effect on FDI, suggesting that reduction of government interference in private sector participation is a less compelling factor in FDI decision making in the region. These results are in contrast to those in Tang (2017), using panel data from Central and Eastern European countries. One reason for the different results could be that the latter countries pursued deeper bank liberalisation and a stronger stock market integration.

The period of our analysis for sub-Saharan Africa corresponds with the reform era when many sub-Saharan African countries adopted the structural adjustment programs (SAP). SAP reforms were designed and governed by the global financial institutions including the IMF and World Bank to reduce internal and external economic distortions and financial imbalances in order to "develop" Africa. Although SAP reforms have resulted in macroeconomic and structural policy changes, they were responsible for hardships and risks to poor and developing countries, consequently, failing in promoting FDI in the region. A possible explanation for this is that sub-Saharan Africa lacked the environment to support SAP reforms given that good governance, low levels of corruption among others are prerequisites for effective SAP reforms (Skosireva and Holaday, 2010). Furthermore, the overall impact of structural reforms has been hindered by various institutional dimensions in these countries not captured. This is along the line suggested by Estrin and Pelletier (2018) who argue that structural reforms do not automatically generate the economic gains in developing countries but rather pre-conditions especially regulatory infrastructure, attention to poverty and social impacts, and the implementation of complementary policies among others are important for achieving a positive impact.

The results in Columns (3) and (4) of Table 13 show the effect of environmental stringency on inward FDI while controlling for structural reforms and other important factors that influence FDI decisions in sub-Saharan Africa and we employ the energy use index as a proxy for environmental regulatory stringency. For host countries' GDP growth rate, there is a negative but statistically insignificant effect on FDI. Return on investment in the region has a negative and statistically significant relationship with FDI, indicating that the return on investment plays a significant role in inward FDI to the region. For example, foreign investors perceive Africa as very risky due to factors such as policy uncertainty, thereby resulting in very low risk-adjusted returns which have a deterrent effect on attracting FDI (Asiedu, 2002).

Human capital has a positive but statistically insignificant effect on FDI. This result suggests that this is not a compelling factor in FDI location decisions in sub-Saharan Africa. A high inflation rate has a negative but statistically insignificant effect on FDI. Furthermore, the empirical literature relating to the role of economic instability on FDI seems to be inconclusive. For example, Asiedu (2002) does not find any significant effect between FDI and inflation rate while Okafor et al. (2015) find a deterrent effect of a high inflation rate on FDI.

A positive but statistically insignificant effect is found for the infrastructure development variables. One possible explanation is that sub-Saharan Africa is characterised by inadequate infrastructure development. This implies that the number of the telephone network in many sub-Saharan African countries are not sufficient and not a compelling factor in attracting inward FDI. This finding contrasts with that of Wagner and Timmins (2009), but who use roads as an alternative proxy for infrastructure development. The sign for agglomeration effects remains the same in all model specifications and exerts a positive and statistically significant effect on FDI.

Natural resource endowments reveal consistently a positive and statistically significant relationship on sub-Saharan Africa's inward FDI. This result is similar to Cleeve et al. (2015) but in contrast to Okafor et al. (2015). Our results demonstrate the fact that the vast majority of the region's FDI inflows are in the resource-rich countries of South Africa, Nigeria and Angola, who are endowed with natural resources such as diamond, gold, oil and gas. On the other hand, relatively resource-poor countries attract little or no FDI, a perception that seems to be consistent with the data (UNCTAD, 2012). This perception also reflects the over-dependence on natural resources and these results are quite similar to the

results of previous empirical studies in sub-Saharan African countries. Asiedu (2006) argues that the implication is the persistent economic stagnation in the region given that investment in such industries tends not to generate positive externalities in terms of technology transfers and employment creation associated with FDI. Also, countries with a higher percentage of minerals and fuels in total exports are more prone to oil price volatility, thereby increasing economic uncertainty in the host economy (Okafor et al., 2015).[17] Furthermore, according to the 2007 report of the United Nations Conference on Trade and Development (UNCTAD, 2007), for countries to turn their abundant natural resources into sustainable development and profit, there is the need for industrialisation and diversification towards creating value-added goods and services from resource extraction before exporting in order to create jobs and promote industries.

The coefficient of agglomeration effects reveals a consistent pattern which exerts a positive and statistically significant impact on sub-Saharan Africa inward FDI. After controlling for structural reforms and other important factors, we obtain a negative and statistically significant relationship between environmental stringency and inward FDI, providing evidence of pollution havens within sub-Saharan Africa. This is consistent with the pollution haven hypothesis, suggesting that foreign investors are attracted by less stringent environmental regulations.

Further, we quantify the effect of environmental regulatory stringency on inward FDI using standard deviation and coefficient estimates from our results. The result implies that an increase in environmental regulatory stringency in a sub-Saharan African country by one unit, on average would lead to a 3% decrease in FDI/GDP per year into the region, we conclude that the deterrent effect of environmental regulatory stringency on FDI is significant. Thus, the more stringent are the environmental regulations the lower is the amount of FDI, suggesting that FDI prefers to locate into regions with relatively weak environmental regulations. This result is consistent with the finding in Zhang and Fu (2008) as well as the finding in Wagner and Timmins (2009). Despite the inconclusiveness of previous empirical studies regarding the significant role of environmental regulation stringency, we find that environmental regulations significantly affect the pattern of sub-Saharan Africa inward FDI. Our findings provide support for the pollution haven hypothesis for sub-Saharan African countries. To check the robustness of our empirical

[17] Sub-Saharan African countries are taking positive steps towards diversification of their economies in recent years (African Development Bank, 2018).

results, we also conducted an analysis by employing the feasible generalised least squares (FGLS) technique given in Table 14.

Table 14 FGLS results using lagged explanatory variables

	WEF stringency		Energy use stringency	
Variables	(1)	(2)	(3)	(4)
Environmental regulatory stringency	-0.051**	-0.045**	-0.030**	-0.026**
	(-2.40)	(-2.09)	(-2.40)	(-2.09)
FDI/GDP	0.857***	0.846***	0.857***	0.846***
	(24.28)	(22.81)	(24.28)	(22.81)
GDP growth	-0.005	-0.005	-0.005	-0.005
	(-0.41)	(-0.38)	(-0.41)	(-0.38)
Return on investment	-35.48***	-33.26***	-35.48***	-33.26***
	(-4.49)	(-4.15)	(-4.49)	(-4.15)
Human capital	0.002	0.003	0.002	0.003
	(0.81)	(1.00)	(0.81)	(1.00)
Inflation	-0.005	-0.005	-0.005	-0.005
	(-0.77)	(-0.94)	(-0.77)	(-0.94)
Infrastructure	0.006	0.005	0.006	0.005
	(0.98)	(0.79)	(0.98)	(0.79)
Natural resource endowments	0.005**	0.005**	0.005**	0.005**
	(1.96)	(2.02)	(1.96)	(2.02)
Institutional quality	0.051***	0.044**	-0.007	-0.006
	(2.78)	(2.41)	(-0.45)	(-0.37)
Financial development		-0.012		-0.012
		(-1.52)		(-1.52)
Bank efficiency		0.006		0.006
		(1.02)		(1.02)
Trade reform		0.012*		0.012*
		(1.79)		(1.79)
Privatisation		-2.335		-2.335
		(-1.48)		(-1.48)
Observations	348	348	348	348
Wald χ^2	3438.66	3526.12	3438.66	3526.12

z-statistics in parentheses. ***significant at %1, **significant at 5% and *significant at 10%.

Columns (1) to (2) present results from the use of the World Economic Forum's environmental regulatory stringency while columns (3) to (4) show results from energy use proxy environmental regulatory stringency. The results are consistent with those from our GLS random-effects specification. After controlling for structural reforms and other important factors that may determine inward FDI, Table 14 displays all the results for this alternative analysis.

Comparing these findings with the previous results as shown in Table 13, shows that all the signs of coefficients of the explanatory variables are the same, thereby

confirming the continued significance of environmental regulatory stringency, agglomeration economies, return on investment, natural resource endowment, institutional quality and trade reform in influencing FDI pattern in sub-Saharan Africa. These findings provide robust evidence that a host country's environmental regulation plays an important role in attracting FDI. Also, agglomeration effects, return on investment, natural resource endowments and trade reforms are important determinants of inward FDI. We also apply an additional sensitivity analysis to energy use environmental regulatory stringency measure.

Table 15 Regression results using percentage of energy use stringency measure

	Random-effects GLS		FGLS	
Variables	(1)	(2)	(3)	(4)
FDI/GDP	0.857***	0.846***	0.857***	0.846***
	(22.62)	(21.10)	(24.28)	(22.81)
Environmental regulatory stringency	-0.180**	-0.157*	-0.180**	-0.157**
	(-2.24)	(-1.96)	(-2.40)	(-2.09)
GDP growth	-0.005	-0.005	-0.005	-0.005
	(-0.38)	(-0.35)	(-0.41)	(-0.38)
Return on investment	-35.48***	-33.26***	-35.48***	-33.26***
	(-4.18)	(-3.84)	(-4.49)	(-4.15)
Human capital	0.002	0.003	0.002	0.003
	(0.76)	(0.93)	(0.81)	(1.00)
Inflation	-0.005	-0.005	-0.005	-0.006
	(-0.72)	(-0.87)	(-0.77)	(-0.94)
Infrastructure	0.006	0.005	0.006	0.005
	(0.91)	(0.73)	(0.98)	(0.79)
Natural resource endowments	0.005*	0.005*	0.005**	0.005**
	(1.83)	(1.87)	(1.96)	(2.02)
Institutional quality	-0.083*	-0.07	-0.083*	-0.072*
	(-1.77)	(-1.52)	(-1.90)	(-1.65)
Financial development		-0.012		-0.012
		(-1.40)		(-1.52)
Bank efficiency		0.006		0.006
		(0.94)		(1.02)
Trade reform		0.012*		0.012*
		(1.66)		(1.79)
Privatisation		-2.34		-2.34
		(-1.37)		(-1.48)
Observations	348	348	348	348
R^2/Log-likelihood	0.836	0.840	779.588	783.561
Wald χ^2	2984.13	3019.50	3438.66	3526.12

z-statistics in parentheses. ***significant at %1, **significant at 5% and *significant at 10%.

We substitute the energy use index by the percentage of energy use. The results presented in Table 15 are consistent with those reached in Table 14. Return on investment

and institutional quality have negative and statistically significant effects on FDI; positive and statistically significant results for agglomeration economies, natural resources and trade reforms; and insignificant results for GDP growth, human capital, inflation, infrastructure, financial development, bank efficiency and privatisation. The empirical analysis supports our results that FDI is attracted to less stringent environmental regulations, confirming the presence of a pollution haven in sub-Saharan Africa.

In summary, the empirical results show that in addition to other important FDI determinants, environmental regulation and structural reforms matter for attracting FDI to sub-Saharan Africa. Furthermore, our main findings on the role of environmental stringency, human capital, macroeconomic stability, infrastructural development, agglomeration effects, natural resource endowments, institutional quality, and structural reforms withstand robustness checks. It is important to note that although this study examines the role of environmental stringency, we argue that in addition to environmental regulations, controlling for fundamental FDI determinants and a number of macroeconomic structural reforms provide a new perspective on FDI decisions in sub-Saharan Africa. Consequently, it is important to control for structural reforms and other important FDI determinants.

5. Conclusion

The relationship between foreign direct investment (FDI) and environmental regulatory stringency has been extensively investigated in the literature on the pollution haven hypothesis (PHH). The evidence in support of the PHH is, however, mixed. Moreover, there is little to no evidence on the PHH in the sub-Saharan African region. This paper examines the effect of environmental regulatory stringency on FDI in sub-Saharan Africa. Alongside investigating the effect of environmental regulatory stringency on FDI in this region, we also assess the role of financial and trade reforms and privatisation of state-owned enterprises. In this paper, we construct a new dataset on structural reforms and environmental stringency based on the energy use approach for 13 sub-Saharan African countries over the period 1985-2012. This environmental measure of environmental stringency is compared with a measure based on the Executive Opinion Survey conducted by the World Economic Forum (WEF).

Using panel data techniques, our results emphasised the importance of controlling for structural reforms and other important determinants of FDI such as agglomeration

effects, return on investment, natural resource endowments, institutional quality, and trade liberalisation. When controlling for those factors, we find that environmental regulatory stringency has a significant and negative effect on FDI, this implies that the more stringent are the environmental regulations the lower is the amount of FDI, leading us to conclude that, all else being equal, FDI prefers to locate in regions with relatively weak environmental regulations. This provides some empirical evidence of a pollution haven effect within sub-Saharan Africa.

The role of structural reforms has a varying impact on FDI. On the one hand, we find that financial reforms and privatisation were not compelling factors that shaped sub-Saharan African countries' inward FDI. On the other hand, we find evidence that trade reform has had a positive and statistically significant effect on inward FDI, suggesting the complementarities between FDI and trade. Our results also provide evidence that MNEs are concentrated in locations where there is an existing stock of FDI. Furthermore, we find that return on investment and natural resource endowments influence FDI decisions in sub-Saharan African countries.

Our results have important policy implications. It is argued that FDI is a catalyst for economic development, however, there is a concern that faster economic development driven by FDI may exert increased pressure on a country's natural resources and environment. Evidence from this study suggests that developing countries with relatively lax environmental regulations do not attract more productive FDI, and consequently cannot benefit from the FDI spillovers. It becomes pertinent that countries pursue adequate economic, structural and environmental policies in order to attract "sustainable" FDI.

In view of the relatively less stringent environmental regulations in sub-Saharan Africa, one policy recommendation from this research is that national governments in collaboration with the expertise from developed countries design sound environmental regulatory frameworks that are in line with international environmental standards in order to strengthen the investment climate of host countries that can shape and support a path to sustainable development. Furthermore, in the last two decades, sub-Saharan African economies have witnessed tremendous economic growth, with average GDP per capita for countries such as Nigeria, Angola, Ghana and Mozambique ranging between 4.7% to 7.6% (Chandy et al., 2013). Our results indicate that the growth prospect shows the untapped opportunities in the region, therefore, improving market potentials, and export

diversification towards promoting manufacturing are important factors that could promote inward FDI.

Another policy recommendation is that respective governments in sub-Saharan African countries should be committed to pursuing effective monetary policy, favourably socioeconomic environment, quality regulatory framework and institutions as these are important factors for successful structural reforms in particular and consequently boosting sub-Saharan African countries' attractiveness as FDI locations. In addition, the importance of infrastructure development in facilitating information, and technological transfer as well as the movement of people, goods and services, cannot be overemphasised. This acts as an impetus to foreign investors, hence further strengthening of infrastructure development in host countries could promote FDI. In addition, given the role of human capital in FDI decision, it becomes necessary that governments in sub-Saharan Africa pursue policies that support R&D and technological innovation which encourages more productive inward FDI by following the example of newly industrialised countries such as Singapore (Chellaraj, et al., 2013).

Finally, there is a strong case to be made for effective structural policies that are not based on aid conditionality where a donor such as the World Bank/IMF offers temporary aid during reform (Asiedu, 2002). Therefore, in partnership with the World Bank and IMF, sub-Saharan African governments should encourage credible and country-led reforms in order to address political resistance and lack of commitment as well as a poor implementation which has often made the SAP reforms ineffective in attracting the anticipated FDI to the region.

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Appendix

Table 16 Definition of variables and sources

Variables	Description and Source
FDI/GDP	Inward foreign direct investment stocks as a percentage of real gross domestic product (GDP) measured in millions of 2011 US Dollars. Source: The UNCTAD FDI/MNEs statistics database and the Penn World Tables
GDP growth rate	The growth rate of real GDP at 2011 US Dollars (%). Source: The Penn World Tables
Return on investment	An inverse of real GDP per capita at 2011 US Dollars (using real GDP in millions of 2011 US Dollars and population). Source: Real GDP and population data from the Penn World Tables
Human capital	The gross secondary school enrolment ratio (%). Source: World Bank Development Indicators database
Inflation rate	The overall macroeconomic instability measured as the consumer price index (%). Source: World Bank Development Indicators database
Infrastructure	The number of telephone mainlines per 1000 population. Source: World Bank Development Indicators database
Natural resource endowments	Total natural resources rent as a percentage of GDP. Source: World Bank Development Indicators database
Institutional quality	Rating of the control of corruption in 2011 which measures the extent to which public power is exercised for private gain, including both petty and grand forms of corruption as well as "capture" of the state by elites and private interests. The ratings range from -2.5 to 2.5, a high rating implies a strong governance performance. Source: Kaufamann et al., 2010; Worldwide Governance Indicators compiled by the World Bank
Financial development	An index from 0 to 1 of financial development in the host country based on three underlying variables the ratio of liquid liabilities to GDP, the ratio of private sector credit to GDP, and the ratio of commercial bank assets to the total bank assets. Source: Beck et al., 2000; World Bank Financial Structure dataset. Author's compilation
Bank efficiency	An index from 0 to 1 of the efficiency of the banking sector in the host country based on the ratio of overhead costs to total bank assets and net interest margin. Source: Beck et al., 2000; World Bank' Financial Structure dataset. Author's compilation
Trade reform	An index from 0 to 1 of trade liberalisation in the host country based on the arithmetic average of normalised average tariff rate and tariff dispersion. Source: The Heritage Foundation's Economic Freedom of the World. Author's compilation

Privatisation	Total government's privatisation proceeds as a percentage of GDP. Source: Kikeri and Koko, 2005; World Bank privatisation database. Author's compilation
Environmental regulatory stringency (WEF)	The stringency levels of environmental regulation in the host country with a range of 1 (lax compared to other countries) to 7 (among the world's most stringent). We use the mean value over the period. Source: World Economic Forum, Executive Opinion Survey
Environmental regulatory stringency (Energy use)	An index of 0 (low regulations) and 1 (high regulations), calculated using the energy intensity in the host country. Energy intensity is defined as total energy use divided by GDP. Source: Cole and Elliott, 2003; the International Energy Agency statistics database. Author's compilation

Definition and calculation of the structural reforms and energy use environmental regulation stringency variables

Financial reforms are measured using two variables namely the overall financial development and bank efficiency.

Financial sector development consists of three variables:

I. The ratio of liquid liabilities to GDP given as currency plus demand and interest-bearing liabilities of bank and nonbank financial intermediaries
II. The ratio to GDP of credit issued to the private sector by banks and other financial intermediaries
III. The ratio of commercial bank assets to the sum of commercial bank assets and central bank assets

Also included is bank efficiency which consists of:

I. The ratio of overhead costs to total bank assets
II. Net interest margin

These variables are normalised to construct financial sector development and bank efficiency indicators following the procedure in Campos and Kinoshita (2010). We normalise the variables by equating the maximum for all countries and all years (or the minimum depending on whether higher values of the variables indicate more or less reform). We calculate the distance from each country-year data point to the global maximum (which is normalise to one) by (i) subtracting each country-year data point from the overall minimum ii) calculating the range for each series, that is, maximum minus minimum and iii) dividing the results from (i) by those from (ii).

Trade reform or liberalisation reflects the openness of the economy to international trade. This comprises of two variables:

I. Average tariff rate
II. Tariff dispersion

These variables are normalised following the procedure above to construct overall trade reform data. Also, privatisation proceeds are normalised.

Energy use environmental regulation stringency indicator is calculated using the change in energy intensity between 1985 and 2012 and the level of energy intensity in 1985. The former was calculated using the averages of the years 1985 and 1986 and 2011 and 2012 in order to reduce the effect of the end-years. The two variables were ranked, these ranks were summed and then ranked again. These values were then divided by the number of countries in our analysis. These values were then subtracted from 1 to obtain an index between 0 and 1, where 1 = high regulations and 0 = low regulations. Source: Cole and Elliott (2003); the International Energy Agency statistics database.

Chapter 3

The Impact of Anthropogenic Factors on CO_2 Emissions for Nigeria and South Africa

Abstract

The short-run and long-run dynamics between CO_2 emissions and its determinants are examined using the Stochastic Impact by Regression on Population, Affluence and Technology (STIRPAT) model. Considering South Africa's commitment to building a cleaner energy mix and improving energy efficiency, this paper conducts a comparative analysis between Nigeria and South Africa to analyse the drivers behind CO_2 emissions for the period 1985-2012. The findings confirm that economic growth and energy consumption are key determinants of CO_2 emissions in both countries. Further, using time series analysis, we find no evidence in support of the environmental Kuznets curve and pollution haven hypothesis while controlling for FDI, trade openness and democracy. While South Africa has maintained a significant reduction in energy intensity and a lesser impact of economic growth on the environment, Nigeria is different. In addition, urbanisation contributes to CO_2 emissions reduction in the short-run in South Africa while population growth does not increase CO_2 emissions in both countries. The results indicate that FDI has a negative effect on CO_2 emissions in Nigeria. This supports the pollution halo hypothesis, which posits that FDI is conducive to the transfer and diffusion of 'clean' (energy) technology. Having pursued a similar economic growth path, South Africa's experience in reducing energy intensity can provide relevant policy lessons for Nigeria in facilitating effective energy and environmental policy.

1. Introduction

In the past decades, one of the most debated aspects of environmental degradation has been the impact of human activities. Previous studies on the impact of anthropogenic activities on the environment are focused on developed countries that rely on cross-sectional data which do not adequately capture the dynamics between human factors and the environment (Panayotou, 2000). A small body of the literature have focused on long time-series analysis on developing economies (Zhu and Peng, 2012) while only a few has investigated the effects of both globalisation and the political economy dynamics in the relationship between human factors and environmental degradation (Rafiq et al., 2016; Lau et al., 2014; Shahbaz et al., 2016b; Adams and Klobodu, 2017; Farzanegan and Markwardt; Lv, 2017). This study aims to fill this research gap and contribute to the existing literature by examining the impacts of anthropogenic factors on the environment.

More specifically, this paper investigates the relationship between FDI and environmental sustainability, measured by CO_2 emissions. We control for trade openness and democracy by using an extended Stochastic Impact by Regression on Population, Affluence and Technology (STIRPAT) model for Nigeria and South Africa over the period 1985-2012. We assess empirically the theoretical predictions of the pollution haven hypothesis (PHH) and the environmental Kuznets curve (EKC). This comparison is motivated by the growing regional collaboration and interdependencies between both countries in recent years (New Economic Partnership for Africa's Development, 2006). As one of the most technologically advanced countries in Africa, South Africa is positioned as a leading country in energy efficiency. For instance, South Africa has been building close collaboration with international organisations such as the International Energy Agency in order to shape a cleaner energy mix and improvement in energy efficiency, renewables and technology.[18] In addition, South Africa is the only African country with a reduction in carbon-intensity while pursuing continued economic growth as a result of adopting nuclear and modern renewable energy (Burke, 2012).

The complex nexus between human activities and environmental impact has been widely studied using different approaches. The most common models used in previous

[18] See the International Energy Agency country profile.

literature include the input-output model, environmental impact of population, affluence and technology (IPAT) or its stochastic form (STIRPAT) model and the log mean Divisia index (LMDI) methods (Lin and Sun, 2010; Xu et al., 2014). The STIRPAT model has been widely used by scholars to examine the drivers of environmental degradation because the model can be expanded to include additional factors and the coefficients of environmental impacts can be estimated (Liu et al, 2015; Dietz and Rosa, 1994).

Several factors have been identified as potential determinants that could affect environmental quality: population, economic activities, technology, political and economic institutions, attitudes, and beliefs (Dietz and Rosa, 1994). However, the impact of these factors on CO_2 emissions are heterogeneous across different countries or regions (Liu, et al, (2015), hence, there is the need to understand the complex relationship between human factors and the environment within a country in order to formulate specific country-oriented strategies which can provide policymakers with insight into the key factors that are potentially conducive to promoting sustainable development.

This study employs the autoregressive distributed lag (ARDL) approach developed by Pesaran et al. (2001). This technique is advantageous because it can be applied regardless of whether the series is I(0) or I(1) or mixed (i.e., stationary at level, first difference or both). Also, unlike other conventional approaches to cointegration, it can be applied to studies with small sample sizes. Furthermore, both short-run and long-run relationships can be simultaneously estimated (Wolde-Rufael and Idowu, 2017). Since a long-run relationship between CO_2 emissions and its determinants has important implications for economic development and environmental quality, a comparative study could provide more insights for analysing the characteristics of population growth and urbanisation, energy consumption and industrialisation processes, trade and investment liberalisation, and democratic institutions which are important in understanding the driving forces of environmental degradation. Furthermore, by applying this approach, we examine the validity of the pollution haven hypothesis (PHH) and the environmental Kuznets curve (EKC) in both countries. The PHH postulates that MNEs relocate factories from high-income countries to low-income countries which are generally considered to have weaker environmental standards (Copeland and Taylor, 1994; Kim and Adilov, 2012). On the other hand, the EKC hypothesis asserts that initially economic growth will lead to environmental degradation but eventually as income increases, environmental degradation will decrease (Grossman and Krueger, 1995; Cole et al., 1997; Shahbaz, et al., 2016).

Many developing countries are experiencing rapid demographic changes and economic growth in recent years. According to the World Development Indicator of the World Bank, economic growth in sub-Saharan Africa is averaged at over 4%. Nigeria and South Africa are the two countries with the fastest growth in income and population in the region. These changes are characterised by increased energy demand and rapid growth in CO_2 emissions driven mainly by the use of fossil fuels such as petroleum and coal in energy production as well as the persistent gas flaring and other oil and gas production activities in the Niger Delta region of Nigeria (Tajudeen, 2015). Soon after the advent of democracy in 1999 and 1994 in Nigeria and South Africa respectively, the average economic growth ranges from 4.3% and 7.6% between 2002 and 2012 (Lin et al, 2016; Shabaz et al., 2013). CO_2 emissions in Nigeria increased from 31.8 million tonnes in 1985 to 64.4 million tonnes in 2015 at an annual average growth rate of 7% (International Energy Agency, 2017). South Africa is the world's most carbon-intensive non-oil producing developing country, measured in per capita carbon dioxide emissions in 2010, and excluding island states, making South Africa the largest emitter of CO_2 than all other sub-Saharan African countries combined (Kohler, 2013).

Although environmental deterioration is a global issue which threatens both developed and developing countries, it has been argued that developing countries are the most vulnerable to its impacts due to existing and increasing poverty and other geographical constraints such as harsh climates, soil and habitat (Shahbaz et al., 2013; Parry et al., 2007). Also, a large part of the population is dependent on primary products, agriculture and natural resources for their livelihood (Madu, 2009). Similarly, rapid population growth has been associated with accelerated changes in consumption and production which result in many environmental problems such as air and water pollution, poor waste disposal and massive energy demand which may have long term effect on human health and a country's resources or productivity (Zhu and Peng, 2012).

Furthermore, in an attempt to diversify the economy, both countries have undergone tremendous economic transformation through rapid urbanisation and industrialisation. These factors can affect a country's resource use and the global environment (Shahbaz et al, 2016). As the most populous country in Africa, Nigeria has a population of over 187 million people, and it is estimated that the country's population will increase to 230 million people by 2025. 46% of the population lives in urban areas and most of this urban population is concentrated in cities such as Lagos, Abuja, Port-Harcourt, Kano and Kaduna

(United Nations Population Division, 2014). South Africa is chosen as a candidate for a comparative study because the experience of Nigeria's economic development is similar to that of South Africa. In both countries, economic development has been driven by rapid urbanisation process and rising energy demand associated with the use of fossil fuels over time, rapid integration into world economies through accelerated economic globalisation which stimulated the introduction of new technologies and expertise (Shahbaz et al., 2013).

There are substantial political transformations in both countries since the last three decades with significant improvement in their democratic institutions. For example, Nigeria improved its policymaking democracy score from 0 in 1985 to 8 in 2016 with a one year transition period in 1998 to democracy, and South Africa from 7 in 1985 to 9 in 2016 with a two year transition period in 1992 and 1993 to democracy.[19] Although, as one of the largest economies in Africa, South Africa exhibit significant differences in demographics, institutions, socio-political structures, international competitiveness, urban and industrial planning, as well as economic development strategies. However, Nigeria can draw lessons from South Africa given its leading role in setting environmental regulation standards, promoting development through urbanisation and improvement in energy consumption behaviour (World Economic Forum, 2015).

In summary, this paper examines the impact of FDI on environmental sustainability measured as CO_2 emissions, concentrating on Nigeria and South Africa as one of the largest recipients of FDI in sub-Saharan Africa. The main contribution of this paper is to show how FDI plays an important role in reducing environmental degradation. The empirical analysis provides evidence for the first time of a pollution halo hypothesis in sub-Saharan Africa, confirming that FDI is conducive to the transfer and diffusion of 'clean' technology and that spillover effects from foreign affiliates to local firms improve the environmental quality of host countries. The findings suggest that greater economic openness and institutional quality in host countries is vital for achieving sustainable development.

The rest of this paper is organised as follows: section 2 describes the literature review, section 3 provides the methodology and data, section 4 discusses the results and section 5 presents the conclusion.

[19] Available at http://www.systemicpeace.org/inscrdata.html.

2. Literature Review

A number of recent studies have examined the relationship between human factors and environmental degradation. The relationship between human factors and environmental degradation is complex. For instance, population growth exerts indirect effects via changes in consumption patterns, production, technology, and trade among others (Zhu and Peng, 2012). Demographic factors, economic growth and technological development are usually acknowledged to be the major determinants of energy use and environmental degradation, and their impact on the environment are shown to be heterogeneous across countries and regions (Liu et al., 2015).

Previous studies on the effects of human factors on the environment have mainly been examined in three ways. The first group of research primarily focuses on the relationship between demographic changes, energy use and environmental pollutant. Previous studies have examined the impact of an increasing population on CO_2 emissions (Daily and Ehrlich, 1992; Birdsall, 1992; Shaw, 1992; Bongaarts; 1992; Knapp and Mookerjee, 1996; Shi, 2003; Harte, 2007; Sanglimsuwan, 2012; Zoundi, 2017). Also, several previous studies focus on the relationship between energy use and urbanisation in increasing CO_2 emissions (Holdren, 1991; Parikh and Shukla, 1995; Satterthwaite 2003; Alam et al. 2007; Daramola and Ibem, 2010; Zhang and Lin, 2012; Liddle, 2013; Al-mulali and Tang, 2013). Satterthwaite (2009) studied the determinants of CO_2 emissions for 184 countries for the periods 1950-1980 and 1980 to 2005. The results show little association between rapid population growth and higher CO_2 emission increase because countries with the highest population growth rates have low CO_2 emissions per capita suggesting that increase in urbanisation rate and changes in consumption levels rather than population growth are the major determinants of CO_2 emissions.

Cole and Nuemayer (2004) considered 86 countries from 1975-1998 and found a positive relationship between CO_2 emissions and a set of explanatory variables including population, energy use, and smaller household sizes. Poumanyvong and Kaneko (2010) analysed the impact of urbanisation on CO_2 emissions and energy use to investigate different development stages across 99 countries from 1975 to 2005. Their findings suggest that there is a positive relationship between urbanisation and CO_2 emissions for all income levels. Fan et al. (2006) using a much larger dataset of 208 countries show that there is a negative relationship between urbanisation and CO_2 emissions. In the case of 22 emerging economies, Rafiq et al. (2016) examined the link between demographics and energy use

over the period 1975-2000. They found that population density increases energy use and CO_2 emissions while urbanisation increase energy use, but this does not increase CO_2 emissions. Zhu and Peng (2012) studied the impacts of population change on CO_2 emissions in China during the period 1978-2008. They find that changes in population size were not the major drivers of CO_2 emissions, but that urbanisation increases CO_2 emissions.

Shahbaz et al. (2016a) claim that there is a U-shaped relationship between urbanisation and CO_2 emissions in Malaysia between 1970-2011, suggesting that urbanisation initially decreases CO_2 emissions, but after a threshold level, urbanisation increases CO_2 emissions. Another important work for this study is that Madu (2009) who use data for Nigeria in 2006 found that there is a positive relationship between population size and CO_2 emissions while urbanisation reduces CO_2 emissions. However, this study covered a limited timeframe that did not adequately reflect the substantial geopolitical and economic changes in the country over the past two decades. Lin et al (2016) conclude that population growth and urbanisation have a negative relationship with CO_2 emissions in African countries (Congo, Egypt, Kenya, Nigeria and South Africa) for the period 1980-2011.

The second strand of literature examines the relationship between economic growth and environmental degradation (usually measured by CO_2 emissions in the literature), primarily testing the validity of the environmental Kuznets curve (EKC), which asserts that economic growth at first tends to increase environmental degradation until a certain income level when environmental quality improves with economic growth (Grossman and Krueger, 1995). According to the EKC hypothesis, an inverted U-shaped relationship exists between economic growth and environmental degradation. In the EKC, economic growth has been shown to be driven to a large extent by energy use which increases CO_2 emissions (Lin et al., 2016).

Barkirtas and Cetin (2017) examined the EKC hypothesis in Mexico, Indonesia, South Korea, Turkey and Australia from 1982-2011 and concludes that EKC relationship does not exist as a higher income level increases CO_2 emission over time. In another study, Onafowora and Owoye (2014) examined the EKC hypothesis in Brazil, China, Egypt, Japan, South Korea, Mexico, Nigeria and South Africa over the period 1970-2010 and conclude that the inverted U-shaped EKC hypothesis is valid for Japan and South Korea only. Bento and Moutinho (2016) argue that economic growth leads to less CO_2 emissions over time from 1960-2011 in Italy, thereby providing evidence for the EKC. In a similar

study from 1961-2010 in Turkey, Bölük and Mert (2015) report an inverted U-shaped relationship between economic growth and CO_2 emissions in support of the EKC hypothesis suggesting that CO_2 emissions increase with income increase then CO_2 emissions starts to decrease with a higher level of income.

Using dataset for 14 Latin American countries from 1980-2010, Sapkota and Bastola (2017) find evidence of the EKC, suggesting that at first economic growth increases pollution and then decreases it after a certain level of income is reached. In another study, Shahbaz et al. (2013) provided support for the existence of the EKC for CO_2 in South Africa during the period 1965-2008. In another study, Nasr et al (2015) find no evidence of the EKC for South Africa. In the case of Nigeria, Madu (2009) reports a positive relationship between economic growth and CO_2 emissions thereby implying no evidence in support of the EKC. Similarly, Lin et al (2016) show that there is no evidence in support of the EKC in African countries (Congo, Egypt, Kenya, Nigeria and South Africa) for the period 1980-2011. In a study done by Shahbaz et al. (2016b) using a dataset of 19 African countries from 1971-2012 find no evidence of the EKC in Nigeria and South Africa.

The third strand of the literature examines the relationship between globalisation and environmental degradation, and focuses on testing the pollution haven hypothesis, which posits that the tightening of environmental regulation in one country will lead to the location or relocation of pollution-intensive production from countries with stringent environmental regulations to developing countries which are generally considered to have weaker environmental regulations, thereby becoming pollution havens (Copeland and Taylor, 1994). In other words, an increase in FDI increases environmental degradation. In recent years, the effects of FDI has been introduced in evaluating the driving forces of environmental degradation. Sun et al. (2017) find evidence of the PHH for China during the period 1980-2012 as CO_2 emissions increased with an increase in FDI. In contrast, Zhang and Zhou (2016) studied the relationship between FDI and CO_2 in China from 1995-2010 and do not find evidence of the PHH. They argue that FDI contributes to CO_2 emission reductions in support of the pollution halo hypothesis. In the case of Ghana, Solarin et al. (2017) find evidence of the PHH as increased FDI increases CO_2 emissions. Kim and Adilov (2012) provide evidence in support of both the pollution haven and the pollution halo hypotheses using a larger dataset of 164 countries from 1961-2004, suggesting that FDI reduces CO_2 emissions in developing countries due to the transfer of cleaner technologies from developed countries while FDI increase CO_2 emissions in developed

countries as foreign firms may relocate from one developed country to another with preference for less stringent environmental standards. Similarly, Shahbaz et al. (2016b) in a study of 19 African countries from 1971-2012 find evidence of a positive link between increased globalisation and CO_2 emissions in South Africa thereby supporting the existence of the PHH but do not find a significant relationship in Nigeria.

The empirical literature on the relationship between human factors and CO_2 emissions (environmental degradation) is extensive, and the findings diverse. The aforementioned studies indicate that research on the impact of human factors and environmental degradation that has focused on Africa is scarce. Also, country-specific studies compared to cross-national studies are few. Moreover, democracy is another important factor that could influence the environmental quality of the host country, however, it has been greatly ignored in the previous literature. It is argued that the relationship between environmental quality and income is interconnected to the political institutions involved in the process of environmental policymaking in a country (Lv, 2017). There are two different views in the literature on the effects of democracy on environmental quality. The first group supports the view that democracy improves environmental quality (Adams and Klobodu, 2017; Torras and Boyce, 1998) while the second view relates democracy to environmental degradation (Hardin, 1968; Paehlke, 1996). Therefore, we contribute to the empirical literature by examining the drivers of environmental degradation in Nigeria and South Africa by controlling for democratic institutions and other important determinants of CO_2 emissions within the STIRPAT model. The comparative study between Nigeria and South Africa could offer new insight on the characteristics of urbanisation, energy use, economic growth, democratic institutions and FDI in order to develop country-specific policy strategies for achieving sustainable development.

3. Methodology and Data

This study examines the driving forces of environmental degradation in Nigeria and South Africa using the framework of the STIRPAT model, an extended version of the original IPAT Identity. The IPAT identity is used to explain the factors driving environmental changes. In particular, it shows the effects of population growth, affluence and technology on the environment (Lin et al., 2016). Following Dietz and Rosa (1994) and York et al. (2003), this paper employs a stochastic form of the IPAT identity (Ehrlich and Holdren, 1971) which can be represented as:

$$I = PAT, \quad (1)$$

In Equation (1), the dependent variable is environmental degradation where *I* denote environmental impact or degradation usually measured in terms of carbon dioxide (CO_2) emissions or other environmental indicators. Since there is no comprehensive data on environmental indicators and industrial pollution in developing countries due to lack of monitoring of many pollutants or other indicators of environmental conditions, we follow the approach suggested in the empirical literature and employ CO_2 emissions as our measure of environmental degradation, defined as total carbon dioxide emissions in metric tons. CO_2 emissions have been widely used as the indicator of environmental degradation in the literature because it is the primary greenhouse gas causing global warming (Cole and Neumayer, 2004; Onafowora and Owoye, 2014). Furthermore, more reliable time series data on CO_2 emissions are available for most countries as compared to other pollutants (Sapkota and Bastola, 2017).

P represents population, *A* represents affluence which is typically measured in terms of GDP per capita and *T* denotes technology. In line with the previous IPAT literature, T is a broad term that is intended to capture technological, cultural and institutional determinants of *I* (Cole and Neumayer, 2004). The IPAT identity has been subject to debate, primarily in relation to the monotonic formulation between the major anthropogenic factors and environmental impact. This monotonicity makes estimating the impact of the driving forces of environmental degradation on the environment inadequate (Dietz and Rosa, 1994). In order to overcome these limitations of the IPAT equation, Dietz and Rosa (1997) proposed the STIRPAT model, which is written as follows:

$$I = aP_t^b A_t^c T_t^d \varepsilon_t \quad (2)$$

where *I*, *P*, *A* and *T* have the same definition as the IPAT framework, *a* is the constant term; *b*, *c* and *d* are the coefficients of *P*, *A* and *T* respectively while subscript *t* denotes the year and ε is the error term. In order to address heteroscedasticity concerns, the STIRPAT model is converted into natural logarithms form (Ouyang and Lin, 2017) as follows:

$$lnI_t = \alpha + \beta_1 lnP_t + \beta_2 lnA_t + \beta_3 lnT_t + \varepsilon_t \quad (3)$$

where *a*, *b*, *c* and *d* in Eq. (2) are replaced by mathematical notations α, β_1, β_2 and β_3 respectively.

The STIRPAT model allows other factors to be included to examine their impact on the environment, such that *P*, *A* and *T* can be decomposable (Dietz and Rosa, 1994). Previous empirical studies have demonstrated that changes in demographic factors such as urbanisation are an important factor in explaining environmental impacts (Sarzynski, 2012). Furthermore, following the STIRPAT literature, a country's structure of the economy is denoted as technology. Following Cole and Neumayer (2004), we use two measures of *T*, energy intensity measured as total energy use per unit GDP and the share of manufacturing output in GDP as proxies for technology. We employ energy intensity, i.e., energy consumption divided by total GDP rather than energy consumption because it is more superior to conventional energy consumption since it controls the income effect of the country. Energy intensity provides a measure of 'energy productivity' as well as energy efficiency level of the country and fundamentally should be directly related to the level and types of technology currently in place in a country, hence the technological advancement in the country (Shahbaz, et al., 2016b).

In addition, manufacturing share in GDP provides a measure of the industrial structure in an economy. Although energy intensity is partly determined by the sectoral structure of the economy, however we aim to capture the impact of technology *T* more comprehensively by following the empirical literature and including both variables in our estimations, however, other aspects of technology not captured by these variables are captured through the error term (Cole and Neumayer, 2004). Furthermore, we avoid problems arising from multicollinearity between CO_2 emissions and energy use and other explanatory variables embedded in the STIRPAT model by the use of an appropriate estimation method such as the application of the autoregressive distributed lagged technique that includes sufficient number of lags to capture the data generating process and includes lags of both the dependent and the explanatory variables (Bento and Moutinho, 2016).

With the increasing integration of world economies due to globalisation, we extend the STIRPAT model by incorporating FDI and trade openness to further examine the driving forces of CO_2 emissions in Nigeria and South Africa. Rafiq et al. (2016) and Lau et al. (2014) have shown that trade openness and FDI are important factors in explaining environmental quality. In this paper, FDI variable is included to model the theoretical basis

of the pollution haven hypothesis (Zhang and Zhou, 2016). The pollution haven hypothesis posits that developing countries that attract foreign investments might also be attracting pollution since environmental regulations in the developing countries are weaker in relation to developed countries (Kim and Adilov, 2012).

The previous literature has shown that the relationship between environmental quality and economic growth depends on political institutions that govern the process of environmental policymaking in a country (Lv, 2017). Furthermore, Farzanegan and Markwardt, 2018 argue that more political freedom and transparency, improved governance, and the rule of law among others can significantly influence environmental quality. Thus, in order to assess the role of political institutions, we control for policy indicators such as democracy. This study, therefore, contributes to the existing literature by examining the effect of democracy on CO_2 emissions. To further analyse the relationship between environmental quality and economic growth, this paper employs an alternative approach as suggested by the literature (Bento and Moutinho (2016) to determine whether there is evidence of the environmental Kuznets curve (EKC) in Nigeria and South Africa.

The EKC hypothesis posits that economic growth has been synonymous with environmental degradation, however, this impact decreases as income increases or as the economy grows (Grossman and Krueger, 1995). We overcome the problem of multicollinearity between the GDP per capita and its squared term usually used to specify the inverted U-shaped relationship associated with the EKC hypothesis and we employ an alternative way of determining whether or not the EKC hypothesis is valid for countries in our analysis, and we follow the empirical literature suggested by Narayan and Narayan, 2010; Al-Mulali et al., 2015; Bento and Moutinho (2016). This approach compares the estimated long-run coefficients of GDP per capita with its short-run coefficients. By applying this approach, if the long-run elasticity is smaller than the short-run elasticity, then we can infer that economic growth leads to a reduction of pollution over time, thus providing support for the EKC hypothesis. This approach also motivates the use of an appropriate estimation technique such as the autoregressive distributed lag (ARDL) method which involves adding sufficient number of lags to reflect the data generating process in general to specific modelling technique and includes lags of both the dependent and explanatory variables, in order to minimise the problem of multicollinearity (Bento and Moutinho, 2016). Therefore, following Kripfganz and Schneider (2016), the ARDL (p, q, …, q) model in this paper is given as:

$$lnCO_{2t} = \alpha_i + \sum_{i=1}^{p} \varphi_i lnCO_{2\,t-i} + \sum_{i=0}^{q} \beta_i' lnX_{t-i} + \varepsilon_{it} \quad (4)$$

where the dependent variable is the total amount of carbon dioxide emissions (CO_2) measured in metric tons. X represents a vector of the explanatory variables. The ARDL model allows the regressors to be I(0) or I(1) or co-integrated. Under this model, the estimated short-run coefficients are consistent, and the long-run coefficients are super-consistent in small sample sizes (Pesaran and Shin, 1999); φ *and* β are coefficients; α is the constant; p and q are optimal lag orders while ε is a vector of error terms assumed to be normally distributed and white noise.

The explanatory variables include population growth measured as annual percentage growth rate; urbanisation measured as a percent of the population living in urban areas; real per capita GDP as a proxy for affluence measured as GDP per capita in constant 2010 US dollars; technology measured as the share of manufacturing in GDP; energy use measured as total energy consumption per unit GDP as another proxy for technology; trade openness which is the sum of exports and imports as % of GDP; FDI is the inward FDI as % of GDP and democracy which captured three essential, interdependent components. First is the presence of institutions and procedures through which citizens can express preferences about alternative policies and leaders. Second is the existence of institutionalised constraints on the exercise of power by the executive, and third is the guarantee of civil liberties to all citizens in their daily lives and in acts of political participation. The democracy variable is an addictive eleven-point scale derived from the coding of the competitiveness of political participation, the openness and competitiveness of executive recruitment and constraints on the chief executive. The higher the value of the index, the more democratic the political system is, while lower values indicate low democracy.[20] Table 17 presents the definition of variables and sources of data.

[20] Available at http://www.systemicpeace.org/inscrdata.html.

Table 17 Definition of variables and sources

Variables	Description and Source
CO_2 emissions	Total metric tons of carbon dioxide emissions stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid and gas fuels and gas flaring. Source: World Bank Development Indicators database
Population growth rate	Annual growth rate of the total population. Source: World Bank Development Indicators
Urbanisation	Percent of people living in urban areas. Source: World Bank Development Indicators
GDP per capita	Real per capita gross domestic product (GDP) in constant 2010 US dollars. GDP per capita is measured as GDP divided by midyear population. Source: World Bank Development Indicators database
Manufacturing share in GDP	Manufacturing value added as a percent of GDP. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. Source: World Bank Development Indicators database
Energy use	Total energy consumption in tonnes of oil equivalent divided by GDP in constant 2010 US dollars. Source: International Energy Agency database
FDI	Inward foreign direct investment stocks as a percent of real GDP in constant 2010 US dollars. Source: The UNCTAD FDI/MNEs statistics and the World Bank Development Indicators databases
Trade openness	Sum of exports and imports as percent of GDP. Source: World Bank Development Indicators database
Democracy	An index from 0 (less democratic political institutions) to 11 (more democratic political institutions) derived from the coding of the competitiveness of political participation, the openness and competitiveness of executive recruitment and constraints on the chief executive. Source: POLITY IV database

Regarding the population coefficient, it is expected that as the population grows, there will be increased pressure on natural resources and land use thereby increasing production and consumption with a greater impact on the environment. Thus, this variable is expected to have a positive effect on CO_2 emissions. The relationship between urbanisation and CO_2 emissions is indeterminate a priori. Urbanisation may have a positive impact on CO_2 emissions via higher energy consumption which is driven by massive housing needs and industrialisation. Alternatively, urbanisation may reduce emissions through its role in economic modernisation and economies of scale (Shabaz et al., 2016a).

Share of manufacturing in GDP measured as the percentage of manufacturing in a country's total output denotes technology which reflects the industrial structure of an economy. The sign for this variable is indeterminate a priori. It is expected that emissions reduce when a country undergoes structural changes from traditional agricultural to manufacturing because there is a change of emphasis from heavy industry associated with rural agriculture towards light industry associated with urban manufacturing and services (Cole, 2004). For example, agrarian economies tend to specialise in the production of goods that are intensive in natural resources, thereby increasing their specialism in heavy industrial sector which involves activities such as deforestation and burning forests to clear land for agriculture and livestock ranching exacerbate CO_2 emissions, alternatively, structural changes involving rapid industrialisation increases emissions through higher energy consumption (Rafiq, et al., 2016). Furthermore, energy intensity measured as the total energy use divided by GDP denotes technology and it represents a country's productivity which is directly related to the type and level of technology (e.g., Cole and Neumayer, 2004). The sign for this variable is expected to be positive, that is, higher energy intensity production or consumption are expected to increase CO_2 emissions.

The globalisation indicator measured as FDI and trade openness captures a country's competitiveness, which is indeterminate a priori. It is expected to have a negative sign if trade openness or FDI reduces emissions through the transfer of cleaner and energy-efficient technology transfer from the developed world to developing economies but it will be positive if more trade or FDI increases emissions and environmental degradation which is driven by rapid economic growth.[21] Since we are interested in the level of activity of MNEs, we use FDI stocks rather than flows because stocks are a close proxy of multinational activity than flows (Kahouli and Maktouf, 2015). Braconier et al. (2005) suggest that using stocks instead of flows may actually be an advantage, for stocks are long term decisions to invest and are less volatile, and less dependent on missing variables, than FDI flows.

Further, this paper assumes that for the pollution haven hypothesis (PHH) to be valid, the coefficient on FDI is expected to be positive, because the PHH suggest that MNEs transfer pollution-intensive industries to the developing countries which are generally considered to have weaker environmental regulations (Copeland and Taylor, 1994). In

[21] Shabaz, et al. (2016b) and Cole (2004) provided studies on trade liberalisation and pollution emissions.

contrast, a negative coefficient implies that an increase in FDI do not increase emissions or environmental degradation because foreign firms can transfer 'greener' technologies. Consequently, technology transfer stimulates energy efficiency thereby reducing emissions. This argument is known as the 'pollution halo' hypothesis (Zhang and Zhou, 2016). The democracy indicator which captures political institutions is indeterminate a priori. It is expected that democracy will exert a positive effect on environmental quality because it encourages the free collection of information about environmental quality and citizens can express their preferences on alternative policies and governments, thereby improving environmental quality. Conversely, a negative relationship between democracy and environmental quality implies that democracies are faced with over-extraction of natural resources and higher environmental degradation because of economic and business freedom of the population (Farzanegan and Markwardt, 2018).

Annual data from 1985-2012 are obtained for Nigeria and South Africa.[22] Many significant events relative to policy or economy will cause breaks in the time-period which may affect other processes. For example, during the period of study, demographic changes characterised by high population growth and urbanisation, rapid economic growth, increased energy demand, industrialisation, investment liberalisation, trade openness and political transition towards institutionalised democracy took place in both countries. Thus, we estimate structural break years because ignoring this important factor can lead to an omission in the model specification and estimation bias, which may lead to wide disparities between estimation results and the actual condition (Sun et al., 2017).

This paper conducts a comparative study between Nigeria and South Africa to examine the similarities and differences of driving forces of environmental degradation using CO_2 emissions. Table 18 provides summary statistics and correlation statistics. Definitions, graphical representations and sources of data are given in the Appendix. The main source of data used in this study are from the World Development Indicators compiled by the World Bank, however, energy intensity, inward FDI stock and democracy variables were obtained from the International Energy Agency database, UNCTAD FDI/MNEs database and the POLITY IV database respectively.

[22] The selection of countries in the study is based on population and GDP growth rates.

Table 18 Summary statistics and correlation matrix

Variables	***ln*CO₂**	***ln*P**	***ln*U**	***ln*Y**	***ln*M**	***ln*E**	***ln*FDI**	***ln*OPN**	**DE**
Nigeria									
Mean	11.095	0.946	3.538	7.327	1.577	-0.75	-2.24	3.988	-1.143
Std. Dev.	0.382	0.026	0.164	0.246	0.416	0.207	0.463	0.297	17.139
Min	10.412	0.914	3.244	7.048	0.880	-1.12	-3.33	3.166	-88
Max	11.559	0.991	3.812	7.789	2.254	-0.53	-1.67	4.404	4
lnCO_2	1.000								
*ln*P	0.582	1.000							
*ln*U	0.596	0.435	1.000						
*ln*Y	0.674	0.755	0.829	1.000					
*ln*M	-0.386	-0.02	-0.60	-0.34	1.000				
*ln*E	-0.634	-0.77	-0.78	-0.99	0.31	1.000			
*ln*FDI	0.254	-0.03	0.848	0.440	-0.51	-0.38	1.000		
*ln*OPN	-0.085	-0.32	0.422	-0.02	-0.65	0.087	0.658	1.000	
DE	0.338	0.263	0.122	0.215	-0.11	-0.20	-0.04	-0.093	1.000
South Africa									
Mean	12.855	0.490	4.027	8.729	2.949	-1.56	-2.18	3.920	1.571
Std. Dev.	0.155	0.289	0.075	0.104	0.171	0.790	0.912	0.162	25.313
Min	12.617	0.046	3.90	8.598	2.565	-1.71	-3.34	3.624	-88
Max	13.129	0.863	4.14	8.919	3.166	-1.47	-0.74	4.289	9
lnCO_2	1.000								
*ln*P	-0.917	1.000							
*ln*U	0.914	-0.91	1.000						
*ln*Y	0.856	-0.77	0.742	1.000					
*ln*M	-0.909	0.814	-0.93	-0.85	1.000				
*ln*E	-0.823	0.799	-0.87	-0.87	0.923	1.000			
*ln*FDI	0.912	-0.92	0.942	0.802	-0.92	-0.90	1.000		
*ln*OPN	0.782	-0.82	0.666	0.825	-0.73	-0.76	0.713	1.000	
DE	0.398	-0.37	0.224	0.350	-0.23	-0.17	0.281	0.492	1.000

Notes: *ln* denotes natural logarithm. CO_2 is carbon dioxide emissions which represent environmental degradation indicator; P is population growth rate; U is the percent of the population living in urban areas; Y is real GDP per capita; M is manufacturing as a percent of GDP; E is energy use as percent of GDP; FDI is real FDI stock; OPN is trade openness; and DE is democracy.

We apply diagnostic tests such as normality of error term, serial correlation, auto-regressive conditional heteroscedasticity (ARCH), white heteroscedasticity and functional form misspecification of the empirical model. The stability of estimated short-run and long-run coefficients are examined using the cumulative sum of squares residuals (CUSUMSQ) tests.

4. Results

The empirical analysis for examining the long-run relationship between the variables is based on the standard cointegration approach by first determining the stationarity properties of the data with tests of unit roots. The results of the unit tests and any break year are presented in Table 19. We applied the Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test to determine whether the series contain unit root problem or not. The results of both tests for Nigeria indicate that all variables except democracy show the presence of unit units at level with intercept and time trend. Furthermore, the share of manufacturing in GDP, energy intensity, trade openness and GDP per capita are stationary at first difference. However, CO_2 emissions, population growth and urbanisation contain unit roots at first difference. For South Africa, the unit root tests show that all variables have unit roots at level with intercept and time trend. CO_2 emissions, the share of manufacturing in GDP, energy intensity, FDI, trade openness and democracy are stationary at first difference. Population growth, urbanisation and GDP per capita contain unit roots at first difference. Hence, this study also applied the Zivot-Andrews unit root test to check for any structural break in these variables. In addition, if the structural break is unknown, we implement the Wald statistics to estimate a single break year.[23] This approach tests the null hypothesis of a unit root with a structural break in both the intercept and time trend.

Since the variables are integrated at I(0) and I(1) with structural breaks and the relatively small sample size in this study, we applied the ARDL bounds test approach developed by Pesaran et al. (2001) to examine the cointegration relationships among the variables and to estimate the long-run and short-run coefficients of the STIRPAT model.

[23] See Perron (2006) for a survey.

Table 19 Results of unit root tests

Variables	ADF unit root test	PP unit root test	Break year
Nigeria			
$lnCO_{2t}$	-2.605	-2.286	
$\Delta lnCO_{2t}$	-3.410**	-4.937***	
lnP_t	-3.941***	-0.847	
ΔlnP_t	-0.578	-3.205	1998
$ln\ U_t$	3.264	-2.496	
ΔlnU_t	-2.407	-1.928	1991
lnY_t	-1.809	-2.302	
$ln\Delta Y_t$	-3.991***	-4.238***	
lnM_t	-0.633	-0.763	
ΔlnM_t	-3.631**	-5.507***	
lnE_t	-2.065	-2.467	
$ln\Delta E_t$	-3.842***	-4.675***	
$lnFDI_t$	-1.788	-1.994	
$ln\Delta FDI_t$	-2.538	-3.582**	2006
$lnOPN_t$	-2.929	-2.762	
$ln\Delta OPN_t$	-9.013***	-9.108***	
DE_t	-5.088***	-5.087***	
South Africa			
$lnCO_{2t}$	-2.597	-2.583	
$\Delta lnCO_{2t}$	-3.782**	-5.414***	
lnP_t	-1.571	-1.327	
ΔlnP_t	-1.208	-1.507	2008
lnU_t	-2.874	-3.820**	
ΔlnU_t	-2.450	-1.745	2002
lnY_t	-1.748	-1.525	
$ln\Delta Y_t$	-2.729	-2.880	2008
lnM_t	-1.599	-1.297	
ΔlnM_t	-3.414	-4.425***	2000
lnE_t	-2.358	-2.308	
$ln\Delta E_t$	-3.590**	-5.615***	1999
$lnFDI_t$	-3.395**	-3.338	
$ln\Delta FDI_t$	-4.672***	-6.167***	
$lnOPN_t$	-2.721	-2.573	
$ln\Delta OPN_t$	-3.521**	-4.910***	1993
DE_t	-2.564	-3.101*	
ΔDE_t	-3.397	-4.841***	1996

Notes: **Δ** denotes the first difference operator. All variables are in natural log except the democracy index. Unit root tests are at level and first difference. CO_2 is environmental impact indicator; P is population growth rate; U is the percent of the population living in urban areas; Y is real GDP per capita; M is manufacturing as a percent of GDP; E is energy use as percent of GDP; FDI is real FDI stock; OPN is trade openness; and DE is democracy. Structural break years are obtained from Zivot and Andrews and Wald statistics if insignificant. The null hypothesis for the ADF and PP tests is that a series has a unit root (non-stationary). The lag lengths are based on Schwartz's Bayesian Information Criterion (SBIC) using the command 'varsoc' in Stata. The unit root tests include both intercept and time trend. *, ** and *** indicate the rejection of the null hypothesis at the 10%, 5% and 1% significance levels respectively.

The bound test employs the *F*-statistics to determine a long-run equilibrium relationship between CO_2 emissions and its determinants by testing the joint significance of the subset of coefficients of the lagged level variables (Bento and Moutinho, 2016). The null hypothesis of no cointegration H_0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = \beta_7 = \beta_8 = 0$ is tested against the alternative hypothesis of a cointegrating relationship H_1: $\beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq \beta_7 \neq \beta_8 \neq 0$. Although the distribution of the *F*-statistics is nonstandard, Pesaran et al. (2001) report two sets of critical values.

The estimated *F*-statistics is compared with the first set of critical values called lower bound and with the second set of critical values called the upper bound. If the estimated *F*-statistics is higher than the upper bound of the critical value, the null hypothesis of no cointegration is rejected. If the estimated *F*-statistics is less than the lower bound of the critical values, then the null hypothesis of no cointegration cannot be rejected.[24]

The results are presented in Table 20 and show there is evidence of a long-run cointegrating relationship among the series for Nigeria and South Africa.

Table 20 Cointegration test for Nigeria and South Africa

Dependent variable: *ln*CO_2	***F-statistics***
Nigeria	18.146***
South Africa	5.415***

Notes: *** indicate significance at the 1% level. The critical values for the *F*-statistics from Narayan (2005) are as follows: *I*(0) 1.88, *I*(1) 2.99 (at the 10% level); *I*(0) 2.14, *I*(1) 3.30 (at the 5% level); *I*(0) 2.65, *I*(1) 3.97 (at the 1% level).

Having established that the series are cointegrated, we proceed to estimate the long-run and short-run coefficients using the following ARDL error correction model:

$$ln\Delta \mathrm{CO}_{2t} = \alpha_0 - \lambda(lnCO_{2t-1} - \phi \mathrm{X_t}) + \sum_{i=1}^{p-1} \delta_{lnCO_{2i}} \Delta lnCO_{2t-1} + \sum_{i=1}^{q-1} \delta_{\mathrm{Xi}} \Delta \mathrm{X}_{t-1} + \varepsilon_t \quad (5)$$

[24] For technical details regarding the computation of critical values, see Pesaran et al. (2001).

where Δ is the first difference operator; λ is the speed of adjustment coefficient i.e. estimate of ECM_{t-1} which determines the speed of the short-run adjustment to reach equilibrium path in long-run; ϕ is the long-run coefficient and X is a vector of explanatory variables, p and q are as defined in Equation (4). Lagged values of $ln\Delta CO_{2t}$ and current and lagged values of ΔX_t are used to model the short-run dynamics. The statistical significance of λ with a negative sign confirms cointegration between the variables. The results are presented in Table 21.

The results in both columns of Table 21 show the estimated short-run and long-run coefficients as well as the error correction term coefficients for Nigeria and South Africa. The error correction term coefficients have the correct negative sign and are statistically significant at the 1% level of significance for both countries. This term indicates the speed of adjustment at which any deviations from equilibrium are corrected in the CO_2 emissions equation. If the value on the coefficient is between -1 and -2, then the error correction term produces dampened fluctuations about the equilibrium path. This implies that instead of monotonically converging to the equilibrium pathway directly, the error correction process fluctuates around the long-run value in a dampening way. However, after this process is complete, rapid convergence to long-run equilibrium is obtained (Narayan and Smyth, 2005). In this study, the error correction term coefficients in the short-run models are -1.064 and -1.637 for Nigeria and South Africa respectively.

The findings in Table 21 show that in the long-run, population growth has a positive but statistically insignificant effect on CO_2 emissions in Nigeria, but in the case of South Africa, this is a negative but also not statistically significant determinant. Our results are similar to those in Satterthwaite (2009) who find little association between rapid population growth and high emission increase because countries with high population growth rates have low emissions per capita. These results may be explained through population's impact on consumption capacity given that if the increase in population is not accompanied by a substantial increase in income and general standard of living, it may not have effect on the consumption capacity of households and therefore may not significantly impact resource and energy use, and consequently CO_2 emissions (Lin et al., 2016).

Table 21 Estimated long-run and short-run coefficients using the ARDL approach

Dependent variable: $lnCO_{2t}$	**Nigeria Coefficient**	**South Africa Coefficient**
Long-run results		
lnP_t	3.781	-0.139
	(1.08)	(-0.81)
lnU_t	-8.069	-11.81
	(-1.58)	(-0.99)
lnY_t	4.616**	0.982**
	(3.00)	(2.36)
lnM_t	0.0491	0.072
	(0.36)	(0.27)
lnE_t	6.786***	1.103**
	(4.50)	(2.51)
$lnFDI_t$	-0.933**	0.008
	(-2.59)	(0.23)
$lnOPN_t$	-0.305	-0.041
	(-1.64)	(-0.26)
DE_t	0.007***	0.0003
	(3.35)	(1.15)
Dummy	0.382***	0.002
	(3.14)	(0.12)
Short-run results		
ΔlnY_t	-2.548*	0.206
	(-1.74)	(0.26)
ΔlnE_t	-3.461**	-0.621
	(-2.38)	(-1.5)
ΔDE_t	-0.006***	0.0004
	(-4.77)	(0.74)
ΔlnU_t	9.807	-114.4*
	(0.82)	(-1.85)
ΔDummy	-0.262***	
	(-2.95)	
ECM_{t-1}	-1.064***	-1.637***
	(-8.10)	(-6.69)
R^2	0.952	0.815
Diagnostic tests		
Test	*F*-statistics [p-value]	*F*-statistics [p-value]
χ^2 NORMAL	0.521 [0.771]	2.859 [0.239]
χ^2 SERIAL	0.021 [0.884]	0.011 [0.918]
χ^2 ARCH	0.702 [0.402]	0.843 [0.358]
χ^2 HETERO	0.28 [0.598]	0.03 [0.859]
χ^2 RESET	0.33 [0.805]	1.52 [0.269]

Notes: *t*-statistics in parentheses

***significant at 1%, ** significant at 5% and * significant at 10%

Δ denotes the first difference operator. CO_2, P, U, Y, M, E, FDI, OPN and DE. CO_2 is environmental impact indicator; P is population growth rate; U is the percent of the population living in urban areas; Y is real GDP per capita; M is manufacturing as a percent of GDP; E is energy use as percent of GDP; FDI is real FDI stock; OPN is trade openness; and DE is democracy. All variables are in natural log except the democracy index. Structural breaks are included in the model using a dummy equal to 1 if a structural break year exists in the series, and 0 otherwise. Because of collinearity issues, the maximal lag in the ARDL model is set to one and the optimal lag length is selected using Schwartz's Bayesian information criterion. The variables lag length (1 0 1 1 0 1 0 0 1 1) for Nigeria and (1 0 1 1 0 1 0 0 1 0) for South Africa were obtained using the 'varsoc' command in Stata.

Further, the results in Table 21 show that in the short-run, the coefficient on urbanisation is positive but statistically insignificant in the case of Nigeria. However, there is a negative and statistically significant relationship between urbanisation and CO_2 emissions in South Africa in the short-run. Our results are similar to those in Shabaz et al. (2016a) in the case of Malaysia, suggesting that higher density in urbanisation helps to achieve the economies of scale that result in lower pollution. However, in the long-run, there is a negative but statistically insignificant effect in both countries. The results may be explained by the fact that according to Dietz et al. (2007) urbanisation has a reduction effect on environmental degradation through some changes in lifestyle, however, this is not the case for countries in this study since urbanisation consists mainly of rural-urban migration with the associated differences in income, values, culture and educational attainment (Madu, 2009). The findings suggest that urbanisation is an important factor in the development experience of both countries, however, the reduction of environmental degradation from urbanisation may be temporary in South Africa.

Regarding the GDP per capita variable, the results in Table 21 indicate that in the short-run there is a negative and statistically significant relationship between economic growth and CO_2 emissions, in Nigeria, however, in the long-run, this is positive and statistically significant. Furthermore, in South Africa, there is a positive and statistically significant relationship between economic growth and CO_2 emissions in the long-run, however, there is a positive but not statistically significant relationship between economic growth and CO_2 emissions in the short-run in South Africa. We compare the long-run coefficients of output with the short-run coefficients of output measured as GDP per capita, to examine the presence of the EKC. These results suggest that from the comparison of the short-run and long-run coefficients, there is no evidence of an inverted U-shaped relationship between CO_2 emissions and economic growth since economic growth has a positive impact on CO_2 emissions in the long-run for both countries. Our results mean that economic growth does not lead to a reduction in CO_2 emissions over time, implying there is no evidence of the EKC in both countries. This finding is consistent with results from previous studies in developing countries such as Saboori and Sulaiman (2013) and Lin et al. (2016) who find no evidence of the EKC. Our results show that a 1% rise in economic growth increases CO_2 emissions by 4.62% in the long-run in Nigeria while for South Africa, a 1% rise in economic growth raises CO_2 emissions by 0.98% in the long-run. The results further suggest that CO_2 emissions increases with economic growth. One explanation for this is the rapid economic growth in recent years which is driven by increased consumption

of energy driven by fossil fuel consumption relative to other sources thereby increasing CO_2 emissions, especially given that Nigeria is one of the top producers and consumers of petroleum and natural gas in Africa which is associated with persistent gas flaring and other oil and gas producing activities in the Niger Delta region of Nigeria (Tajudeen, 2015). Furthermore, South Africa's CO_2 emissions were driven by a deliberate strategy of the pre-democracy government prior to 1994 that encouraged investment in energy-intensive industries such as aluminium and other non-ferrous metal beneficiation termed the so-called 'mineral-energy complex' identified by Fine and Rustomjee (1996); and also, the carbon-intensity of a largely i.e. over 90% coal-based electricity generation base (Kohler, 2013).

The technology variable measured as the share of manufacturing in GDP has a positive but statistically insignificant effect on CO_2 emissions in both countries as shown in Table 21. A possible explanation for this is that industrialisation in both countries is at its initial stages and consists of more assembling plants with relatively small amounts of industrial activities. Also, energy use as a percent of GDP which is another proxy for technology has a negative and statistically significant effect on CO_2 emissions in the short-run in Nigeria, but this is not significant in South Africa. In contrast, there is a positive and statistically significant association between energy use and CO_2 emissions in the long-run for both countries during the period of study.

The results in Table 21 point to the fact that CO_2 emissions are highly affected by energy intensity and one plausible explanation for this is that the primary sources of energy in both countries are mainly from fossil fuels (oil, coal and gas). This result show that a 1% increase in energy use will reduce CO_2 emissions by 3.46% in the short-run and raises CO_2 emissions by 6.79% in the long-run in Nigeria, while for South Africa a 1% increase in energy use will increase CO_2 emissions by 1.1% in the long-run, however in the short-run there is a negative effect, but this is not statistically significant.

For both countries in this study, the short-run parameters of energy intensity are negative, and the long-run parameters of energy intensity are positive because the level of economic growth in both countries has reached the point where CO_2 emissions are increased by an increase in energy use. Our results mean that energy intensity increases CO_2 emissions over time. This could be due to the high energy demand which is mainly driven by the use of fossil fuels (oil, coal and gas). This suggests that energy use is the leading factor causing CO_2 emissions in both countries, thereby supporting the view that energy use is an important determinant of environmental degradation. Our results are in

line with those from Onafowora and Owoye (2014) who find a long-run relationship between energy use and CO_2 emission levels in Nigeria and South Africa. It is important to note that South Africa's CO_2 emissions arising from economic growth and energy intensity are relatively smaller, suggesting that Nigeria is different. This is mainly because of South Africa's leading role in setting environmental regulation standards, promoting development through urbanisation and improvement in energy consumption behaviour (World Economic Forum, 2015).

Regarding the role of FDI in environmental degradation, in the case of Nigeria FDI has a negative and statistically significant effect on CO_2 emissions in the long-run. This suggests that increased FDI contributes to the improvement of environmental quality in Nigeria. This finding is contrary to the pollution haven hypothesis (Copeland and Taylor, 1994) but consistent with the pollution halo hypothesis and the research by Zhang and Zhou (2016) who indicate that FDI stimulates the capacity of foreign firms to implement 'greener' technologies from developed to developing countries so as to increase environmentally friendly domestic production. However, for South Africa, there is a positive but statistically insignificant association between FDI and CO_2 emissions in the long-run. One explanation for this may be the prevalence of domestic investment in relation to FDI in recent years (World Economic Outlook, 2017).

For both countries, in the long-run trade openness shows a negative relationship with CO_2 emissions however it is statistically insignificant. One possible explanation may be due to the existence of international trade restrictions such as import barriers (tariffs and taxes) or poor trade liberalisation policies. During the period of study, both countries adopted the structural adjustment programs (SAP) based mainly on the neoliberal "Washington Consensus". More specifically, SAP reforms were designed and governed by the IMF and World Bank which aimed at eliminating restrictions in the economy and liberalising trade among others. Although SAP has resulted in macroeconomic and structural policy transformations, they were unsuccessful in promoting international trade. This may be due to the lack of an enabling environment to support SAP such as good governance, low levels of corruption and functional democracy among others which are prerequisites for effective SAP (Skosireva and Holaday, 2010).

In Table 21, the impact of democracy on CO_2 emissions in Nigeria is negative and statistically significant in the short-run but has a positive and statistically significant effect on CO_2 emissions in the long-run. In the case of South Africa, democracy has a positive impact but statistically insignificant in the short-run and long-run. The findings are similar

with those in Lv (2017) who show that higher levels of democracy increase environmental degradation in lower-income countries and that a reduction in environmental degradation could only be achieved if the country has reached a certain development level given that environmental quality increase as income increases (Farzanegan and Markwardt, 2018). Although both countries have experienced tremendous democratisation over the past decades, there is a high level of illiteracy, inequality, lack of civil liberties and widespread corruption across institutions which may result in democracies not having a positive impact on environmental quality (Harrison, 1992). These results further suggest that stronger political and democratic institutions can play a crucial role in improving environmental quality in both countries. The coefficients of the dummy variables shown in Table 21 indicate that there is a structural break in the economy during the period. Although this is statistically insignificant in South Africa, these periods coincide with the political transition era of democratisation in 1998 and 1993 for Nigeria and South Africa respectively.

We perform several diagnostic tests to verify that the results of our analysis are robust and reliable. The results in Table 21 reveal that the model passes all diagnostic tests. The diagnostic tests examine serial correlation using the Breusch-Godfrey LM test, heteroscedasticity using the Breusch-Pagan test, ARCH test for conditional heteroscedasticity, the Jarque-Bera normality test based on a test of skewness and kurtosis of residuals, and the Ramsey regression equation specification error test (RESET) for omitted variables or functionality form misspecification. This suggests that there are no problems of misspecification, heteroskedasticity, higher-order autocorrelation or normality in the model.

Finally, to check the robustness of the ARDL results, the stability of the estimated long-run coefficients is examined. The stability of these coefficients is tested using methods developed by Chow (1960), Brown et al. (1975), Hansen and Johansen (1993). Based on these techniques, this study employs the cumulative sum of squares tests (CUSUMSQ) based on the recursive regression residuals. The test incorporates the dynamics of the short-run to the long-run through the residuals. The graphical plots for both countries of the CUSUMSQ statistics are given in the Appendix and these are within the 5% critical bounds of parameter stability confirming the efficiency of estimates in the model.

5. Conclusion

This study examines the determinants of CO_2 emissions in Nigeria and South Africa over the period 1985-2012 using the Stochastic Impact by Regression on Population, Affluence and Technology (STIRPAT) empirical framework. We extend the STIRPAT model by analysing the role of FDI, trade openness and democracy. We investigate the validity of the pollution haven hypothesis (PHH) and the environmental Kuznets curve (EKC) for both countries. This paper establishes a long-run relationship between CO_2 emissions and its determinants using the autoregressive distributed lag (ARDL) technique with a structural break. Results show that population growth does not seem to play a significant role in CO_2 emissions in both countries. Urbanisation has a negative effect on CO_2 emissions but only in the short-run in South Africa. Economic growth and energy use are the most important drivers of CO_2 emissions in both countries. The empirical results suggest that economic growth has a negative effect on CO_2 emissions in the short-run but a positive impact in the long-run in Nigeria.

Similarly, in South Africa economic growth has a positive impact in the long-run, however, we do not find a statistically significant short-run relationship. These findings point to the lack of evidence for the EKC hypothesis in both countries. Therefore, we conclude that an inverted U-shaped relationship between economic growth and CO_2 emissions, that is, the conventional EKC hypothesis does not hold for Nigeria and South Africa. Furthermore, energy use exerts a positive impact on CO_2 emissions in both countries in the long-run, although it declines significantly in the short-run in Nigeria. We find that FDI is negatively related to CO_2 emissions. We do not find evidence of "pollution haven" in both countries. Our study supports the pollution halo hypothesis in the case of Nigeria, which posits that FDI can also export 'greener' technologies from developed to developing countries with associated spillover effect thereby improving environmental quality. Also, there is a negative relationship between trade openness and environmental degradation, however, this is not a significant determinant. The results of the analysis show that the share of manufacturing in GDP does not have a significant impact on CO_2 emissions. Results also show that democracy has a negative effect on CO_2 emissions in the short-run but exerts a positive impact in the long-run in Nigeria. For South Africa, democracy does not seem to play a significant role in environmental quality.

The implication of these results on sustainable development in both countries is that appropriate policies should be directed towards energy efficiency by reducing heavy

reliance on fossil fuel and investment should be directed on alternative energy sources especially renewables such as solar, biomass and thermal are required to reduce CO_2 emissions or environmental degradation. Demographic changes pose a major challenge in environmental sustainability in both countries given the indirect effects on consumption patterns, production, investment, trade and energy demand. The urbanisation process and FDI reduces CO_2 emissions by modernisation and its associated changes in lifestyles and technological spillover effects respectively, therefore, adoption of economic, investment and energy policies that are compatible with efficient energy use and economic growth is very paramount for governments and policymakers. Also, democracy is an important determinant of CO_2 emissions in both countries. Although the evidence is not statistically significant in South Africa, it, therefore, seems to indicate that strengthening both countries' democratic institutions through transparency and accountability of the government as well as providing suitable tools towards promoting civil liberties such as free speech, assembly and association can improve environmental quality.

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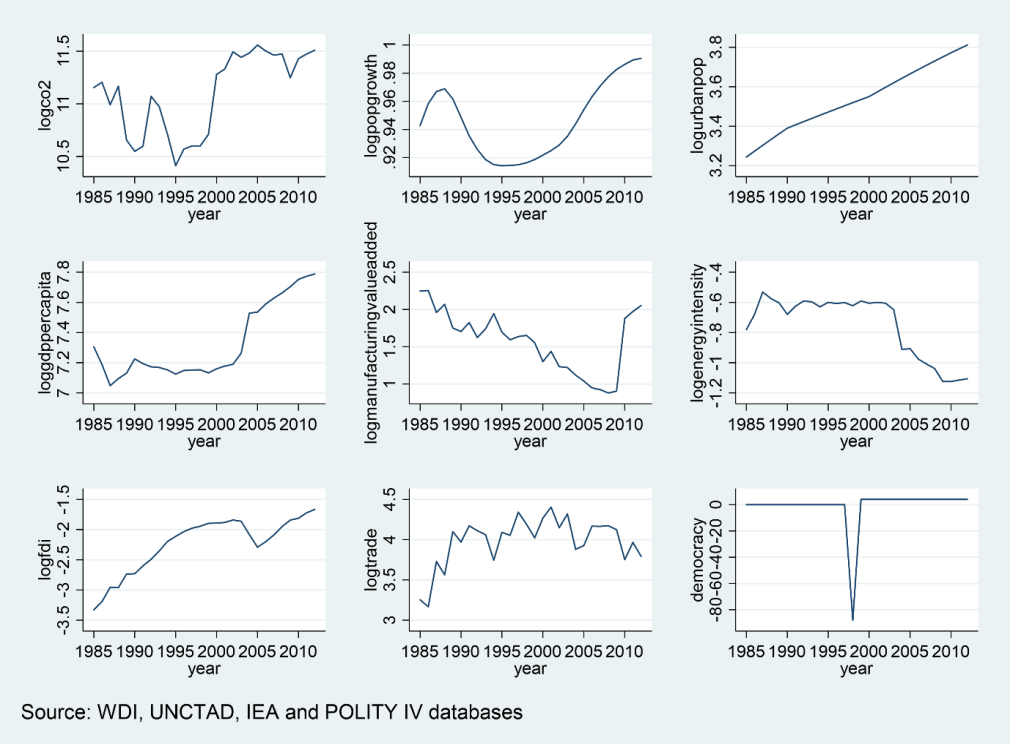
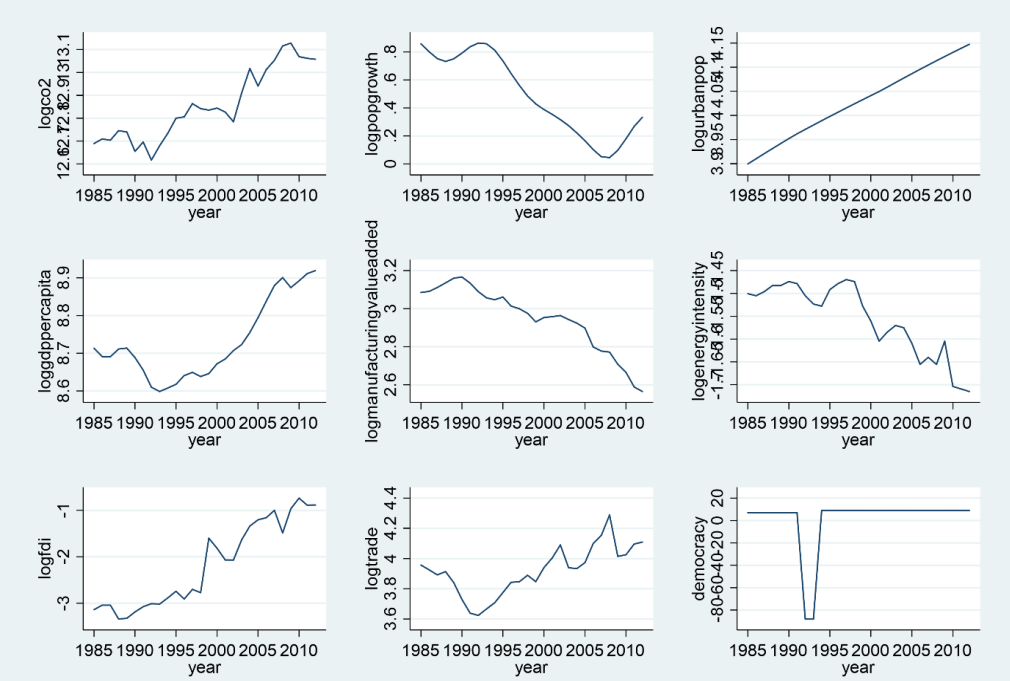
Appendix

Figure 5 Graphical representation of data (Nigeria)



Source: WDI, UNCTAD, IEA and POLITY IV databases

Figure 6 Graphical representation of data (South Africa)



Source: WDI, UNCTAD, IEA and POLITY IV databases

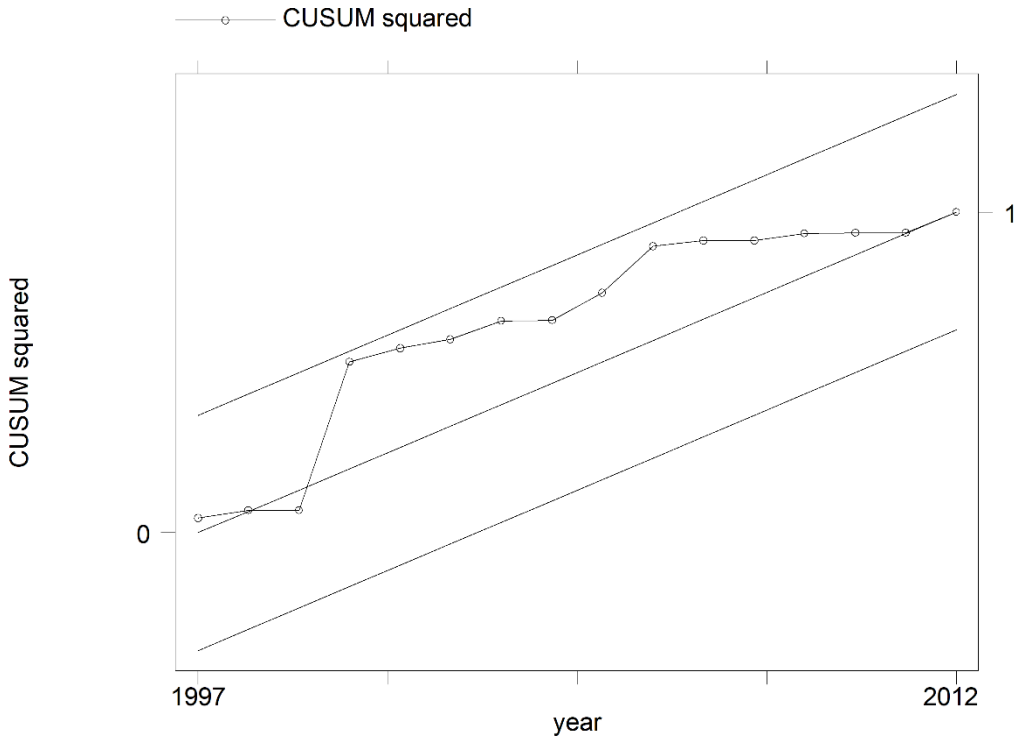


Figure 7 Plot of CUSUMSQ for model stability at 5% level of significance (Nigeria)

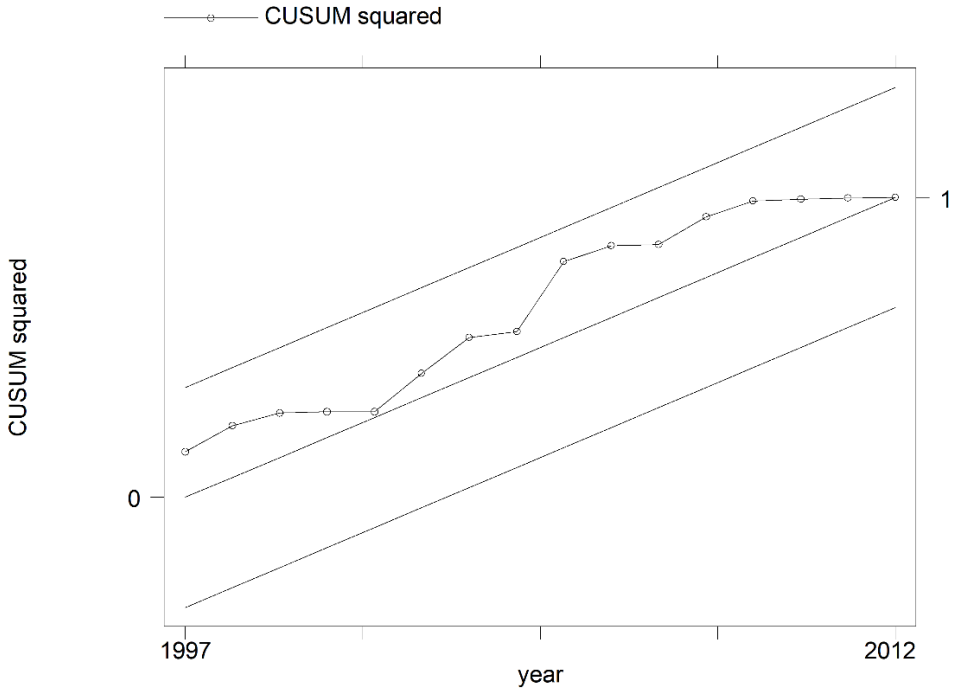


Figure 8 Plot of CUSUMSQ for model stability at 5% level of significance (South Africa)

Conclusion

In this thesis, we provided a novel framework to examine the determinants of inward FDI and the relationship between FDI and environmental sustainability in sub-Saharan Africa. First, we analysed a modified knowledge-capital (KC) model of multinational enterprise that combines horizontal and vertical motives for FDI using a bilateral panel dataset on 30 OECD parent countries and 28 sub-Saharan African host countries during the period 1985-2012. Based on this model, multinational activity between countries is a function of country characteristics such as economic size, size differences, relative endowment differences, trade and investment costs, and certain interactions among these variables (Carr et al., 2001).

Further, we considered the dynamic nature of international investment while controlling for natural resource endowments, governance and institutional quality, structural reforms and relative environmental regulatory stringency. The findings validate the theoretical predictions of the KC model, providing evidence for horizontal and vertical motives for undertaking FDI in sub-Saharan Africa. This suggests that both horizontal and vertical FDI are important to economies in the region and respective governments should attempt to attract both. In addition, trade and investment costs are major factors affecting FDI in sub-Saharan Africa. The control of corruption and structural reforms were fewer compelling factors in attracting inward FDI to the region. In addition, we find a positive relationship between relative environmental regulatory stringency differences of the parent and host country and inward FDI. This suggests that there is a pollution haven in sub-Saharan Africa. Following this, there is a strong case to be made for MNEs to harmonise their environmental practices across parent and host countries to reflect high environmental standards in order to discourage growth in pollution havens.

Second, we employed an aggregate variable framework using a panel data technique and a recently compiled dataset for structural reforms and environmental regulation stringency based on energy use for 13 sub-Saharan African countries during the period of review. We analysed the relationship between environmental regulatory stringency in sub-Saharan Africa. We assessed the role of structural reforms in attracting FDI to the region while controlling for other important factors such as agglomeration economies, level of development, return on investment, human capital, macroeconomic conditions,

infrastructure development, natural resource endowments, governance and institutional quality.

The empirical evidence indicates that the level of environmental regulatory stringency in sub-Saharan African countries play an important role in FDI decision and that high environmental stringency has a deterrent effect on productive inward FDI. The paper finds some evidence for the existence of a pollution haven in sub-Saharan Africa. Therefore, effective environmental policy is required for the region to attract productive FDI and to further reduce environmental impact. The study provides support for agglomeration economies, suggesting that foreign investors are influenced by the presence of other multinationals in sub-Saharan Africa. Furthermore, the results suggest that multinationals are attracted by natural resource endowments in resource-rich economies such as Angola, Nigeria and South Africa. Return on investment, governance and institutional quality are vital factors influencing FDI decisions in sub-Saharan Africa. Trade reform has a positive impact on FDI in sub-Saharan Africa, confirming the complementarities existing between international trade and FDI. The findings indicate that other structural reforms such as financial development, bank efficiency and privatisation of state-owned enterprises were not successful in attracting productive FDI during the period of review. There is, therefore, a need for respective governments to strengthen institutions and further develop financial markets, banking regulations and private sector investment.

Third, we applied the Stochastic Impact by Regression on Population, Affluence and Technology (STIRPAT) framework to investigate the effect of FDI on environmental sustainability measured by CO_2 emissions, in a comparative analysis of Nigeria and South Africa. Having pursued a similar economic growth path and considering South Africa's leading role in energy efficiency and commitment to building a cleaner energy mix through investing in renewables, South Africa's valuable experience can play an important role in facilitating energy and environmental policy framework for sustainable development in Nigeria.

Further, using time series analysis, we provide short-run and long-run relationships between CO_2 emissions and its determinants. The results indicate that urbanisation is an important factor in improving environmental sustainability in the short-run in South Africa. Regarding the impact of economic growth on the environment, the findings indicate that in the long-run, a 1% increase in economic growth resulted in less than a 1% increase in CO_2 emissions in South Africa. However, in Nigeria, a 1% increase in economic growth resulted

in a 2.5% decrease in CO_2 emissions in the short-run and a 4.6% increase in the long-run. Similarly, a 1% increase in energy intensity resulted in 1.1% increase in CO_2 emissions in South Africa while for Nigeria 1% increase in energy intensity resulted in 6.8% increase in CO_2. These results suggest that economic growth and energy intensity are the major drivers of CO_2 emissions in both countries, however, while South Africa has maintained a significant reduction in energy intensity and a lesser impact of economic growth on the environment, Nigeria is different. We find no evidence of both the EKC hypothesis and PHH. There is a negative relationship between inward FDI and CO_2 emissions in Nigeria in the long-run, suggesting FDI plays a vital role in reducing CO_2 emissions. This confirms the positive relationship between FDI and environmental sustainability. Furthermore, population growth, industrialisation and trade openness had no significant effects on CO_2 emissions in both countries. Governance and democratic institutions are important determinants of CO_2 emissions. The results also suggest that strengthening governance and democratic institutions could improve environmental sustainability.

Based on the findings, an appropriate trade and investment policy to improve the investment climate in host countries should be pursued by respective governments in sub-Saharan Africa and other countries interested in attracting productive FDI. Also, macroeconomic structural reforms should be country-led in order to stimulate national commitment to reforms. In addition, good governance, institutional quality and infrastructure development are important to effective reforms and overall FDI performance in host countries. Establishing close collaboration with international organisations and OECD countries to formulate and implement energy and environmental policies to accelerate the energy transition process in developing countries towards a more balanced energy mix through investment in renewable energy technologies is key to reducing energy intensity and CO_2 emissions for sustainable development.

Finally, we, therefore, emphasise that research on FDI and sustainable development also analyse ‘dirty’ industry in developing countries. In addition, tax and labour reforms may be considered. A comparative analysis including sub-Saharan African and non-sub-Saharan African countries may be considered.