Energy Security, Trade and Transition to Green Economy in Africa

By

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Abstract

Environmental challenges have enhanced renewed focus on the need to drive the economy in an economically, socially and environmentally sustainable manner; therefore resulting to the emergence of the concept of green economy. In driving the economy towards a green growth path, the pattern of trade and security of energy will play a vital role. Energy (renewable) has been identified as one of the 6 sectors that would provide trade opportunities for export markets in the transition towards a green economy, particularly for developing economies, Africa inclusive. This paper assesses how the interaction of trade and green economy strategies could promote energy security in Africa for the period 1995 to 2014. The study examines this relationship in forty-two African economies and addresses energy security based on the IEA definition which captured energy security using the indicator of affordability (access) and sustainability (environmentally friendliness). The study situates its theoretical root in the EKC hypothesis and the energy ladder hypothesis and the estimation procedures were based on the dynamic panel approach using the System-GMM with collapsed instrument option. The study found that the indicators of green growth and trade were important determinant of energy security in Africa. This suggests that drive for greener growth agenda enhances provision of clean energy. Also, the present export structure and trade openness of African economies contributes inversely to energy access and environmental sustainability respectively.

Key words: Energy security; Green economy; Sustainable development; International trade,

JEL Codes: F18, Q27

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1. INTRODUCTION

Environmental challenges in particular, climate change impact have enhanced renewed focus on the need to drive the economy in an economically, socially and environmentally sustainable manner. This has resulted in the emergence of concepts such as Sustainable Development (SD), Green Economy (GE), Green Growth (GG), green jobs, low carbon growth (development) strategy and other related terms. The Africa Development Bank (AfDB) has established that green growth and by extension, green economy is compatible with Africa's priorities as their Africa Development Report-ADR (2012) was dedicated to strategising for green growth in Africa. The need to reassess new approaches to enhance environmental quality has become important especially in the face of the threat presented by these environmental challenges resulting in variations in rainfall, unpredictable temperature changes, to mention a few (Osabuohien *et al*, 2015). The importance of this for Africa stem from the fact that despite the continent been one of the least contributor to concentration of greenhouse gases, it has been recognised to be most vulnerable due to its topography among other factors (Akinyemi *et al,* 2015).

Africa has experienced an increased pace of growth in the past decade. In the past decade, Sub-Saharan African countries grew at an average of 5 per cent (AfDB, 2012). It is recognised that economic growth is essential in Africa in order to improve living standards, build resilience and alleviate widespread poverty; however, for this growth to be sustainable, it would have to be on a path that is economically, socially and environmentally sustainable. Thus, a development that will be sustainable will not grow the economy with today's resources at the expenses of the future generation as is said to be with the current pattern of industrialisation. Currently, the industrial and transport (road especially) sectors were identified as the biggest fossil fuel consumers in Africa, accounting for about 22 percent and 47 percent respectively of total fossil fuel consumption in 2009 (ADR, 2012). Continuing this trend according to the scientific report of different scientists that had established the evidence of climate change can continue to heat up the atmosphere. With a view to slowing down the heating of the earth surface, conscious efforts are to be made globally to change the structure of growth and development to give way for a more sustainable pattern.

It is believed that, on the one hand, the pattern of trade in the past decades due to industrialisation has placed pressure on natural resource base of many economies and contributed to the emission of greenhouse gases (GHGs). On the other hand, the oil crisis of 2008/2010 created concerns on energy security, thereby calling for the need to switch to alternative sources of energy that are affordable, reliable, accessible and cleaner for sustainable economic development. In this regards, if energy is to be a determinant for competitiveness, it has to be produced, distributed and consumed in a sustainable manner. In the exchange of goods and services, competitiveness will be enhanced when they are "green" goods and services (i.e. environmentally friendly) with sound technologies and infrastructure. Support mechanisms, policies and reforms must therefore be geared towards this direction.

The interaction of favourable international trade and energy security when accompanied by appropriate regulation and policies can foster transition to a green economy. In this respect, trade has the capacity to foster efforts towards transition to a green economy, particularly for developing countries. It can also ensure adequate security of energy resources. This is in view of the opportunities presented by international trade at the wake of the realisation that only a growth path that is green can be sustainable. However, this can only be possible when the trade exchange is for environmentally friendly goods as against environmentally harmful energy sources such as fossil fuel. Many of the African economies are blessed with abundant renewable energy resources such as solar power, wind and geothermal energy, hydro, biomass, biofuels, among others (UNEP, ITC and ICTSD, 2012). The adequate utilisation of these resources can enable these countries export surplus energy to other countries in addition to providing cleaner and affordable electricity for the population thereby also ensuring energy security and achieving a greener economy. This can be through enhanced sustainable resource use, eradication of poverty and generation of economic opportunities and employment. However, available statistics suggests that a significant proportion of energy export in Africa is largely fossil fuel production-based. According to ADR (2012), over 70 percent of crude oil, about 55 percent of dry natural gas and 23 percent of coal with China and Europe as their major trading partners.

There exists trade opportunities in the energy sector in transiting to a green economy. Such opportunities include investment in new technology and infrastructure that are green and export of “raw materials or components for renewable energy supply (RES) products or even their finished goods” (UNEP, ITC and ICTSD, 2012). Some of these products are mainly solar panels, hydraulic wind turbines and solar water heaters. There is evidence that some emerging economies such as India have experienced substantial growth through the export of these products (UNEP, ITC and ICTSD, 2012; UNEP, 2013). Also, as the world begins to become environmentally aware, the export market for green products is expected to expand especially as consumer preferences continue to change (UNEP, ITC and ICTSD, 2012). The rationale is that, as consumers’ demand for green goods and services grows, the incentive and will for companies and industries to produce these green products also increases; including the adoption of more sustainable manufacturing methods. Another aspect of opportunity for trade in transiting to a green economy is through development of the biofuel industry. It is expected that significant export opportunities are likely to emerge. In particular, biofuel will play a crucial role in the transport sector without necessarily creating competition with food production since biofuel is produced from forestry and agricultural residue. Relevant policies and reforms can then be integrated with these opportunities to expand the capacity of developing countries to benefit. In other words, their successes will be based on design and implementation of appropriate policies and regulation by policy-makers.

The fact that fossil fuel continues to dominate energy supply and trade which might continue into the future in many African countries poses a challenge for the green growth agenda implementation (OCED, 2011; IEA, 2014) and by extension, trade competitiveness. Furthermore, ADR (2012) recognised one of the challenges for green growth in Africa as competition between fossil fuels and other low-carbon options. This is in view of the fact that fossil fuel as an energy resource represents the basis for Africa’s energy sector given the continent’s large contribution to total primary energy supply from International Energy Agency (IEA) statistics. To achieve the transition to green growth in Africa, the role of policy drive cannot be over emphasised. For instance, low-carbon energy options need to be incorporated into the present energy mix structure of many African countries. Policies targeted towards the promotion of green economy must then be founded on the understanding of the determinants of green growth and the related trade-offs and synergies. This study thus attempts to investigate the state of green economy initiatives in Africa and associated trade-offs and synergies as it relates to the role of trade and energy security.

2. REVIEW OF RELATED LITERATURE

A vast amount of empirical literature exist in analysing the link between energy and growth with some including international trade as part of the intervening variables. Many of these studies focused on examining the link between energy and trade openness (e.g. Lean and Smyth, 2010; Ghani, 2012; Sardorsky, 2012; Shahbaz, Nasreen, Ling and Sbia, 2013; Dedeoglu and Kaya, 2013; Shanbaz, Khan and Tahir, 2013; Tsiotras and Estache, 2014; among others), while a few others assessed the trade-carbon leakage-growth nexus (e.g. UNCTAD, 2000; Jena and Grote, 2008; Reinaud, 2009; Sustainable Prosperity Policy Brief, 2011). However, the threats of environmental concerns such as climate change, energy security and human health which has presented a challenge for global development, has necessitated the need to re-access the prevailing approach to growth. This has resulted in a global consensus on the urgent need to transit to a more sustainable growth path thereby paving the way for the concept of Green Economy (GE). Literature on the green economy/green growth concept is still growing and many of the materials available are reports of organisations include UNEP, UNDP, OECD, IEA, AfDB, UNCTAD, European Environment Agency (EEA) among others. Many studies share a general consensus that green growth/green economy is an appropriate policy in transiting to a low-carbon world. Efforts are on-going to identify an indicator for green economy or green growth especially as it relates to modelling. This section thus, discusses some of the issues from the literature on how energy security and trade can enhance the transition to a green economy for African economies.

Conceptually, there is yet to be a consensus definition for green economy or green growth. However, a common indicator in the different definitions indicate that it is an economy that projects a growth model that does not just grow the economy economically, but puts into consideration social equity and environmental sustainability (Akinyemi, Alege, Osabuohein and Ogundipe, 2015). The UNEP views green economy as an economy that "results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" (UNEP, 2014). It is an economy that emphasises low carbon, resource efficiency and social inclusiveness (Klein, *et al*,. 2013). It also calls for the elimination of environmentally harmful subsidies (fuel subsidy) and introduction of green taxes and energy efficient technology in production technology.

The UNEP report on the green economy argue that many of the global crisis experienced which is connected to climate change, food, energy and finance, are as a result of investment in a "brown economy" (such as support for fossil fuels) instead of green sectors (such as renewables). In order to achieve long-term sustainable development, African countries will have to adapt their growth models in a manner that would involve taking green growth and green economy concepts into consideration (Klein *et al.,* 2013). This buttresses the importance of the transition to GE for Africa. Though most African countries are yet to have a comprehensive national document for green growth, some of the plans are embedded in objectives of different programmes. For instance, one of the objectives of the Renewable Energy Programme by the Federal Ministry of Environment of Nigeria is to develop and implement strategies towards achieving a clean reliable energy supply including alternative energy sources (Akinyemi, Alege, Osabuohien and Ogundipe, 2015). This is an aspect of the green economy agenda. Towards the achievement of green economy in Africa, the trade and energy sectors are expected to play a crucial role as established in literature on trade opportunities for green economy transition.

The security of the supply of energy can be enhanced through the development of renewables which is equally a cleaner alternative to fossil fuel. Energy security as a crucial component of any energy policy entails the uninterrupted availability of energy resources at an affordable price in addition to being reliable and accessible (International Energy Agency-IEA, 2014). It is a broad concept and thus definition is often based on context and perspective of evaluation. This approach is vital due to the strategic role of energy in economic development process. This is evident in why energy access is often an integral aspect of any government agenda as this is the channel through which energy influences growth and development. Thus, the adequate security of energy resources enhances sustainable development.

As stated by Borok, Agandu and Morgan (2013), it is the availability of diverse energy resources, sustainable in quantities, affordable in prices, that supports economic growth, assists in poverty alleviation, does not harm the environment and considers disruptions and shocks. The energy crisis recently experienced globally in the past few years has necessitated the need to re-examine innovative ways of ensuring the security of energy in a more sustainable manner. This has resulted in steps towards reforming certain policies in the energy sector that may hinder efforts towards tackling climate change. An example is the reform of fossil fuel subsidies which is categorised as been environmentally harmful. Support for fossil fuel subsidies has been identified as one of the challenges in the switch to green growth in many economies. Energy security should not just entail making energy available, affordable, reliable and accessible; but also ensuring that its production, distribution and consumption support environmental standards. Many countries are making attempts towards designing appropriate policies to address energy security challenges and environmental sustainability.

A viable energy policy that will produce result should be able to adequately balance energy security, economic growth (inclusive of trade competitiveness) and environmental concerns. There is therefore need for African economies to make conscious efforts at developing adequate policy framework towards driving green growth in Africa. Africa been richly endowed with abundance of natural resources, presents a viable case for green economy and one avenue to achieve this is through the transformation of the energy sector. This transformation involves changing the process of producing, delivering and consuming energy. If the goal is to protect global environment, raise living standards and ensure reliable energy supplies, green growth is important and inevitable (OECD, 2011). Many studies and reports in the past have thus pointed out the need to exploit and enhance the commercialisation of renewable energy sources such as solar, wind, hydro, biomass and biofuels as a viable means towards ensuring energy security globally. Also, given the demands of transiting to a GE, the renewable energy market will play a strategic role.

Trade on the other hand, can enhance transition to green economy and likewise, a transition to a green economy can foster greater trade opportunities through the development of export markets for green products (UNEP, 2013). The 2012 Rio+20 conference and many of its reports were intended to establish the positive links between trade and the environment. The report by ITC, UNEP and ICTSD (2012) recognised trade as a two-edged sword. While it depletes natural resources thereby contributing to pollution and carbon emissions, it can also be useful in driving the transition to a GE by fostering sustainable management of resources, disseminate green technologies, create jobs and reduce poverty. In relation to trade in Africa, the pattern and volume has been getting some attention. This relates to the need to enhance the quality of products been exported from Africa as a large part of exports from many African countries are commodity exported in their raw forms. This has not helped in their competitiveness on the global scale when compared to other continents. According to UNEP (2013), world trade patterns show that least developed countries' exports are still dominated by natural-resource based products and raw materials suggesting the need to diversify.

Furthermore, increased international demand has resulted in an intense pressure on natural resources in these countries paving way for detrimental social and environmental impacts such as inequality, environmental degradation and loss of biodiversity. Thus, adequate investment in technology and infrastructure coupled with relevant policies and regulation can reverse this observed trend and pave way for the transition to a greener economy that will improve growth performance, support social inclusiveness and also promotes environmental quality. International trade will represent a useful channel in spreading GE gains among countries at the global level as it plays a central role in the diffusion of green growth services, technology and production methods (UNCTAD, 2011). Some of the trade policies identified by UNCTAD (2011) that are capable of driving GE are green protectionism and co-operation to prevent potential trade disputes.

Therefore, trade opportunities in the energy sector can be exploited to sustain a green economy or green growth model. This is in terms of developing export markets for environmentally friendly products such as renewables (solar panel, hydraulic wind turbines, solar water heaters, among others). The joint report of UNEP, ITC and ICTSD (2012) assessed trade opportunities as it relates with the transition to green economy, particularly how developing countries can increase exports to respond to international demand for environmentally-friendly goods and services. The report identified the energy sector (renewable) as one of the key sectors with potential to enhance trade opportunities in the switch towards adopting a green economy. By 2030, 10 per cent of the global agricultural and forestry residues could provide 50 per cent of biofuel demand (UNEP, *et al*, 2012). A key factor in driving international trade opportunities for green economy as stated by UNEP, ITC and ICTSD (2012), is the changing of consumer demand in developed countries. However, creating and taking advantage of these green export opportunities will require a sustained collaborative effort of world leaders, civil society and leading business firms (UNEP, ITC and ICTSD, 2012). On the hand, this shift must be accompanied by adequate policies to reduce against the impacts that often arise from trade such as pollution and emission from the transport sector and other forms of pressure on the natural resource base (UNEP, 2013).

Despite the evidence of the economic, social and environmental benefits from "greening trade"; however, there are identified challenges and obstacles. These challenges include trade protectionism and related conditionalities. Studies such as UNEP, UNCTAD and UN-DESA (2011); UNCTAD (2012), have stated that trade protectionism can hinder the transition to the path of green economy. UNEP (2013) presented some of the challenges as relating mostly to limitations in human and financial resources, weak regulatory frameworks, inadequate enforcement mechanisms, illiteracy, limited access to energy and poor economic infrastructure.

In addition, reducing trade-related emissions is another obstacle in achieving more sustainable trade and mitigating climate change (UNEP, 2013). Thus, empirical analyses relating to this area have identified a fair, open and transparent process as key component in the transition in order to mitigate associated risks. Rather than focus on the risk of trade protectionism associated with green economy policies, there should be a shift towards improving trade performance in many of the developing countries. Some of the enabling conditions as itemised in the report by UNEP (2013) centre on investment and spending, use of market-based instruments, national and international regulatory frameworks, dialogue and capacity building.

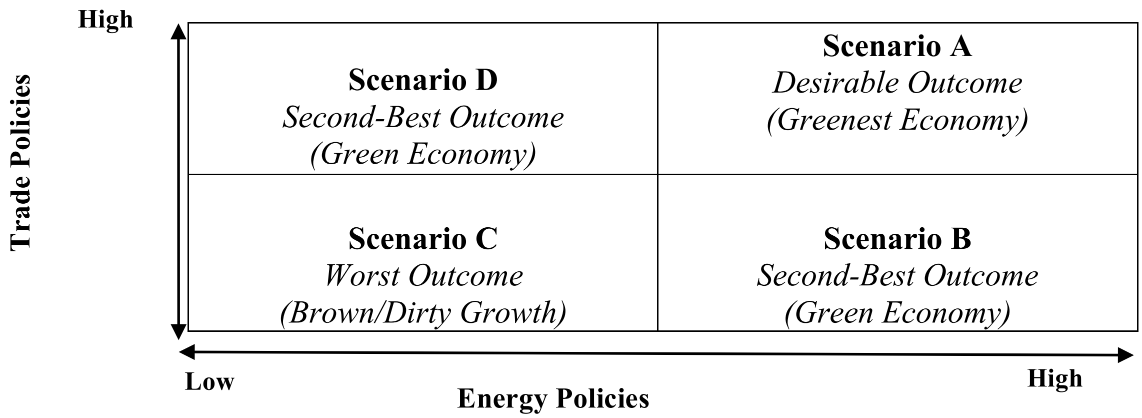
In analysing green economy prospect in five Sub-Saharan African countries, Klein *et al.* (2013) asserted that there is no general rule in achieving GE in the context of SSA, the transition which is promoted within the framework of sustainable economic development will require the joint effort of relevant ministries responsible for growth and the private sector. The creation of awareness and capacity building will be helpful in highlighting the economic benefits of the transition to a GE. Overall, it is evident that growing trade in environmental goods and services, implementation of sustainability standards coupled with the greening of global value chains has the capacity to increase the share of sustainable trade thereby having the potential to significantly influence world trade patterns (UNEP, 2013).

3. ANALYTICAL FRAMEWORK AND METHODOLOGY

3. 1 Typology of Green Economy

This sub-section presents the analytical framework and corresponding typology in analysing the interrelationship between trade and energy security as it relates to green economy. Figure 1 thus presents four scenarios of different outcomes in transiting to a green economy via trade performance and energy security. Scenario A shows a situation of high energy security combined with high level improvement in trade which is the desired outcome where the economy is "greenest". In the case of Scenario B and C, this is the second best outcome where there is an attainment of a green economy. This is where there is either a high level of energy security and low trade quality or high trade quality with a low energy security. It portrays the trade-off between the two variables, in other words, it might not be possible for some developing economies like many in SSA to achieve high level of trade performance and energy security at the same time. Each economy might then have to build on whichever they have comparative advantage. The final case which is Scenario D is the realm of "brown" or "dirty" growth which is the worst outcome. In this case, trade performance is low with accompanying low energy security. To depart from this point and move towards transiting to a green economy, policies and regulation will have to drive strategic sectors in such an economy. The growth model of such economy will not be sustainable in the long-run as resources are been depleted at the expense of the well-being and social development of the citizenry.

Figure 1: Typology of Green Economy anchoring on Trade & Energy Policies



Source: Authors'

3.2 Method and Analysis

Data Sources and Measurements

The study used a longitudinal data for the period 1995 to 2014 for forty-two African countries. The data used include: CO_2 intensity, energy access (percentage of population), electric power transmission and distribution losses, energy price, investment in energy sector, trade openness, share of services export in total export, share of manufacturing exports in total exports, GDP per capita and green growth indicators were obtained from the World Development Indicators of the World Bank while data for institutions were obtained from the World Governance Indicators 2014 of the World Bank.

Model Specification

The description of energy security adopted is similar to the International Energy Association (IEA) definition. Energy security suggests the uninterrupted supply of clean energy at cheap cost. Hence, energy is termed secured if it is accessible to all (affordability) and environmentally friendly (sustainable). A number of extant studies on energy security adopt descriptive approaches while due non-availability of data studies from Africa are largely limited. The study adopts two basic models, one views energy security from the point of sustainable environment (energy sustainability model) and the second sees it in terms of energy accessibility (energy accessibility model). Also, the model takes theoretical root in the Environmental Kuznets Curve (EKC) hypothesis, the Pollution Haven Hypothesis (PHH) and the Energy Ladder Hypothesis (ELH). The two models developed in this study are presented as follows:

$$acs_{it} = \alpha_0 + a_1 mepe_{it} + \alpha_2 egls_{it} + \alpha_3 gdpk_{it} + \alpha_4 egpr_{it} + \alpha_5 sete_{it} + a_6 einv_{it} + inst_{it} + \varepsilon_{it} \ldots 1$$

$$co2int_{it} = \beta_0 + \beta_1 opns_{it} + \beta_2 egls_{it} + \beta_3 gdpk_{it} + \beta_4 egpr_{it} + \beta_5 sete_{it} + \beta_6 einv_{it} + inst_{it} + \varepsilon_{it} \ldots .2$$

The variables adopted in the model are described below:

$mepe_{it}$: commitment of manufacturing (proxied by the share of manufacture exports to primary exports)

$egls_{it}$:electric power transmission and distribution losses (% of output)
$gdpc_{it}$:energy price (proxied by international pump price for gasoline)
$egpr_{it}$: GDP per capita (constant 2005 US$)

$sete_{it}$:green growth (proxied by share of service exports in total export volume)
$einv_{it}$:investment in energy sector
$inst_{it}$:institutions (average values of four measures of institutions provided by the World Governance Indicators- government effectiveness, regulatory quality, rule of law and control of corruption)
$opns_{it}$:trade openness (share of import and export to GDP)
$co2int_{it}$:CO_2 intensity (kg per kg of oil equivalent energy use)

Technique of Estimation

The study adopts a panel data analysis, the estimation exercise is preceded by conducting the multicollinearity test; this examines the possibility of collinear dependence among the explanatory variables adopted in the study. Consequently, the study primarily adopted a dynamic panel data estimation procedure. The choice is premised on the fact that the ordinary least square pooled regression has been criticised in various studies (Alege and Ogundipe 2013; Ogundipe, Ojeaga and Ogundipe 2014) particularly where the lagged dependent variable enters the set of explanatory variables. Likewise, the static regression techniques, though, accounts for country specific heterogeneity and its transformation could provide lags of the variables as instruments implying the consistency of estimates. However, such consistency is not applicable to short panels. In short panels, the static regression eliminates individual heterogeneity but does not account for the issue of persistency of the dependent variable. Thus, regression analysis of our model require a better method of estimation (preferably, the system GMM) in situation where regressors can be endogenous, there is short time dimension in panel and finding a perfect exogenous variable(s) becomes cumbersome (Bond 2002; Buhai 2003).

4. EMPIRICAL RESULTS

Table 1 and 2 shows the result of multicollinearity tests. Table 1 presents the pairwise correlation coefficients while Table 2 shows the result for variance inflation factor. While the latter possesses a standard decision rule, the former rely extensively on the researchers' intuition on acceptable degree of collinearity. This pre-estimation examination is pertinent, as it becomes extremely cumbersome to ascertain the unique effect of the explanatory variable(s) in the presence of a very high or perfect collinear relationship among regressors.

The pairwise correlation coefficient shows the highest value of collinear relationship to be about 39 percent. Since multicollinearity is entirely a problem of degree, this is permissible as it impossible for two economic variables to be void of some form of relationship. Importantly, Table 1 shows a negative correlation between openness and the indicator of green growth. Also, a positive collinear relationship is witnessed between openness and GDP per capita. This implies that, though, openness promotes growth but unchecked openness could hamper green growth agenda.

Table 1: Pairwise Correlation Coefficients

Var.	mepe	opns	egls	gdpk	sete	egpr	einv	inst
mepe	1.0000							
opns	0.2584	1.0000						
egls	-0.2205	0.1818	1.0000					
gdpk	-0.0518	0.3910	-0.1039	1.0000				
sete	0.3238	-0.0035	-0.2420	-0.0748	1.0000			
egpr	0.0047	-0.0067	-0.0032	-0.0794	0.4409	1.0000		
einv	0.0076	-0.0525	0.0136	0.0352	0.0073	-0.0909	1.0000	
inst	0.3771	0.0335	-0.1198	0.2743	0.2970	0.0836	0.0040	1.0000

Source: Computed using Stata 11.0

This has mostly surfaced in the developing economies where goods from industries in advanced economies (with cost and capital advantage) frequently permeate. Finally, positive collinear relationships exist between institutions and the indicator of green growth. Succinctly put, strengthening institution quality in terms of restricted enhances the green growth strategies in African economy

Table 2: Variance Inflation Factor

Accessibility model			Sustainability model		
Var.	VIF	1/VIF	*Var.*	VIF	1/VIF
Inst	2.71	0.3689	*inst*	2.76	0.3618
gdpk	2.55	0.3922	*gdpk*	2.65	0.3772
sete	1.81	0.5537	*sete*	1.63	0.6151
mepe	1.51	0.6631	*egls*	1.26	0.7929
egls	1.23	0.8128	*opns*	1.19	0.8432
einv	1.15	0.8666	*egpr*	1.15	0.8702
egpr	1.14	0.8734	*einv*	1.14	0.8744
Mean VIF	1.73		*Mean VIF*	1.68	

Source: Authors' Computation using Stata 11.0

In the same manner, the result from the variance inflation factor (VIF) seems consistent with pairwise correlation coefficients. The decision rule specifies that multicollinearity becomes problematic when VIF statistics is greater than 5 or the tolerance (inverse of VIF) becomes approximately zero. A vivid observation of table 1 and 2 show no evidence of collinear relationship among the explanatory variables, hence, the separate influence of the regressors become assessable.

Table 3 presents the regression results for the energy accessibility model. As highlighted in the preceding section, energy security is captured via an indicator of its accessibility. Here, the OLS and the static panel regression show that energy security is more responsive to energy price and the indicator of external trade. This implies that affordability and commitment to manufacturing exports are critical to the supply of uninterrupted energy. Bearing in mind that the focus of our estimation procedure is based on the dynamic regression, we proceed to interpret the SYS-GMM result. Here, all the explanatory variables were significant in explaining energy security except institutions.

Table 3: Energy Accessibility Model

	OLS	*Static Panel Regression*		*Dynamic Panel Regression*
	OLS	*Fixed Effect*	*Random Effect*	*GMM(Collapsed)*
VARIABLES	*acs*	*acs*	*acs*	*acs*
L.acs				0.964***
				(0.0188)
mepe	14.49***	1.060	5.911***	-1.062***
	(1.624)	(2.054)	(1.900)	(0.226)
egls	-0.308***	0.0756**	0.0469	-0.0185
	(0.0556)	(0.0336)	(0.0349)	(0.0129)
gdpk	0.00822***	-0.00109	0.00322***	0.00104***
	(0.000938)	(0.00148)	(0.00121)	(0.000357)
egpr	-8.829***	9.980***	7.676***	2.452***
	(2.918)	(1.792)	(1.774)	(0.569)
sete	17.44*	7.209	11.04	5.195**
	(8.953)	(13.98)	(12.58)	(2.079)
einv	4.715***	0.156	0.126	0.463***
	(0.603)	(0.368)	(0.383)	(0.0980)
inst	-6.112*	-5.950*	-3.533	-0.669
	(3.122)	(3.322)	(3.244)	(0.613)
Year				-0.147***
				(0.0386)
Constant	-49.19***	36.63***	29.02***	284.3***
	(11.70)	(8.548)	(9.529)	(76.49)
Observations	298	298	298	292
R-squared	0.616	0.171		
Number of id		23	23	23
Year FE				YES
F-test (Wald χ^2)	*66.45*	*7.89*	*54.40*	*84259.22*
F-test (p-values)	*0.0000*	*0.0000*	*0.0000*	*0.000*
Sargan				*0.982*
Hansen				*0.938*
AR(1)				*0.072*
AR(2)				*0.899*
No. of instruments				*17*
Hausman test		*25.62*		
Hausman (p-values)		*0.0003*		

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Source: Authors' Computation using Stata 11.0

Similar to the evidence obtained using the static regression, the indicator of green growth, energy price and commitment to manufacturing exerts the highest variation on energy security. This implies that as the green growth agenda ensures the provision of physical infrastructure that drives service delivery, energy security is guarantee. Since energy services are central to ensuring quality service delivery (such as communication, transport, commerce etc), the drive for ensuring transmission from dirty growth to clean growth also advances the provision, availability and accessibility of energy services. Also, consistent with economic theory, accessibility of any product is a critical function of the ability of an individual to pay its worth. As seen in table 3, a unit increase in energy price dwindle its access by about 2.5 units. This implies that for every 100 percent price hike in energy, its access falls by about 300 percent.

On the other hand, commitment to manufacturing exports exerts a significant negative variation on energy security. A one unit increase in commitment to manufacturing export reduces energy security by about 10.6 units. This is not fat fetched, as there is weak commitment to expanding manufacturing exports in developing African economies. For most African countries, manufacturing exports falls below 5 percent with about 95 percent being commodity exports. Since primary commodities from which most African economies earn over 90 percent of their foreign earnings requires no value addition or processing of any sort, there is less commitment on the part of policy decision makers to improve energy infrastructures. This portrays the high reliance on the use of traditional biomass in most rural Africa.

Consequently, GDP per capita exerts a positive and significant variation on energy security. Though, the impact seems negligible, as a unit rise in average income raises energy access by a meagre magnitude of about 0.001. it implies that a 100 percent increase in average income could only enhance energy access by one-tenth of a unit. This evidence can be rightly be linked to high cost of clean energy in Africa, that is, the cost of clean energy nearly outweighs the ability of consumers to pay for it. This has resulted into wide use of alternative energy sources (mostly unclean with dire social, economic and environmental implications) for heating, lighting and cooking.

It is worthy to note that energy transmission and distribution losses exert a significant and negative variation on energy security. A one unit increase in energy lost reduces its access by 0.02; that is, a 100 percent increase in energy lose dwindles its access by 2 percent. This implies that energy lost during production, transmission and distribution processes reduces its availability and eventually impacts negatively on what is accessible for household use. The incidence of distribution losses is quite high in some African economies. In Nigeria, for instance, energy losses reached about 35-40 in the period 1990-2013 as found by Ogundipe, Akinyemi and Ogundipe (2015).

On the other hand, energy investment exerts a positive and significant influence on energy security in Africa. This is consistent with economic reasoning, as investment should enhance returns. A one unit increase in energy investment culminates into about 0.46 positive returns on energy access. This implies that a 100 percent rise in investment in energy services in terms of enhancing energy physical and personnel infrastructures will increase its uninterrupted availability at a cheap cost by about 4.6 percent.

Finally, the indicator of institution does not significantly influence energy security in Africa. This would not be unconnected to the generally weak status of institutions in Africa. Effective institutions are needed to ensure that energy policies are adequately situated; energy projects are initiated, appropriately financed and efficiently executed. These tripartite interconnections are missing in most African economies, in most cases, budgeted funds are diverted, and projects are poorly executed and eventually abandoned. For instance, evidences showed that between 1983 and 1999, there were no meaningful investment in the Nigeria's electricity sector, the gas conversion plants master plan has long been abandoned and between 1999 and 2007 a whooping US$16 billion was adjudged to have been spent on the power sector without any visible increase in accessibility.

In order to ensure the robustness of our parameter estimates, the study adopted some specification diagnosis tests, these includes the Arrelano-Bond test for autocorrelation, test of instruments validity and the F-test for the overall significance of our regressors. The Arrelano-Bond test is conducted on the differenced residuals in order to purge the unobserved and the perfectly autocorrelated idiosyncratic errors. This is shown as AR(1) and AR(2) at the lower panel of Table 3, the significance of AR(1), and not necessary AR(2), implies that the successive values of the residuals are not serially correlated. The Sargan and Hansen J tests assess the over-identifying restriction of whether our instrument vector is exogenous, the test statistics failed to reject the null hypotheses, hence, the validity of our instruments is guaranteed. Finally, the F-statistic, a small sample counterpart of the Wald (Chi-Square) statistics shows that the exogenous variables jointly explained significantly the observed variation in energy security in Africa.

Table 4: Energy Sustainability Model

	OLS	Static Panel Regression		Dynamic Panel Regression
	OLS	Fixed Effect	Random Effect	GMM(Collapsed)
VARIABLES	co2int	co2int	co2int	co2int
L.co2int				1.178***
				(0.144)
opns	0.108	0.0771	0.0790	0.324**
	(0.117)	(0.0576)	(0.0576)	(0.143)
egls	-0.00729***	-0.00346***	-0.00365***	-0.00755***
	(0.00195)	(0.00108)	(0.00107)	(0.00284)
gdpk	0.000393***	0.000107**	0.000143***	0.000259**
	(3.33e-05)	(4.32e-05)	(3.88e-05)	(0.000128)
egpr	-0.449***	0.0813	0.0611	0.104**
	(0.102)	(0.0585)	(0.0566)	(0.0422)
sete	1.230***	0.187	0.273	-1.008***
	(0.296)	(0.459)	(0.420)	(0.300)
einv	0.138***	0.00873	0.00917	-0.000441
	(0.0211)	(0.0121)	(0.0120)	(0.00725)
inst	0.141	0.0947	0.151	0.450*
	(0.111)	(0.109)	(0.105)	(0.255)
Year				-0.0165**
				(0.00825)
Constant	-1.475***	1.145***	1.039***	
	(0.412)	(0.280)	(0.325)	
Observations	304	304	304	209
R-squared	0.630	0.082		
Number of id		23	23	22
Year FE				YES
F-test (Wald χ^2)	*71.86*	*3.48*	*36.24*	*876.91*
F-test (p-values)	*0.0000*	*0.0014*	*0.0000*	*0.000*
Sargan				*0.946*
Hansen				*0.996*
AR(1)				*0.020*
AR(2)				*0.043*
No. of instruments				*18*
Hausman test		*78.42*		
Hausman (p-values)		*0.0000*		

Notes: Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Source: Computed using Stata 11.0

Table 4 presents the energy sustainability model; here energy security is captured using the carbon dioxide intensity of per capita energy use. The OLS and the static panel regression shows that the indicator of green growth, openness, energy price and institution exert the highest influence on energy security. This implies that the green growth strategies, the degree of trade openness, the ability to pay for clean energy sources and strength of institutional arrangement are critical factors in ensuring the accessibility of sustainable energy. For in-depth discussion, our focus rests absolutely on the SYS-GMM (the collapsed option) due to the inherent estimate challenges in the OLS and static regression procedure. As previously identified; the SYS-GMM result shows that the indicator of green growth, openness and energy price were the main important determinants of energy security in Africa. The indicator of green growth exerts a negative and significant influence on emissions intensity. That is, as the share of services in total exports increases by say, a unit, the emission intensity of energy use falls by about 1 unit. This implies that a 100 percent increase in services exports reduces emissions intensity by about 100.8 percent. It then infers that economy transmission from dirty subsistence traditional and manufacturing phase to services oriented stage, the incidence of carbon emissions reduces and ensures provision of clean and sustainable energy services.

Also, trade openness exerts a positive and significant influence on energy security; as an economy becomes more open, emission intensity increases. That is, if an economy experiences an 100 percent rise in its openness, threats to energy insecurity rises by about 32.4 percent. This is consistent to the Pollution Haven Hypothesis (PHH), as industries in advanced economies with stricter environmental regulations migrates their dirty industries to countries (Africa) with weak environmental regulations. In the same manner, the weak institutional arrangement in Africa economies has consistently enhance the incidence of dumping, where high pollution emitting goods and products permeate into African markets. It hereby implies that in the absence of sound and quality institutional framework capable of regulating the activities of multinational corporations and check excessive openness, trade could promotes emission intensity and hampers the provision of sustainable energy.

In the same manner, energy price exerts a positive and significant influence on energy security; as a unit increase in price increases emission intensity of energy use by 0.1 units. That is, a 100 percent increase in price raises emission intensity by 10.4 percent. This implies that as clean energy sources becomes expensive, about 10 percent of the populace are hereby displaced and resulted into using alternative sources, which are mostly traditional biomass and dirty stoves for heating, cooking and lighting purposes. Also, GDP per capita exerts a significant and positive influence on emission intensity in Africa. That is, a unit increases in GDP per capita increases emissions by about 0.0003. Though, the impact is negligible but consistent with the EKC hypothesis, which specifies that emissions increases with income at the initial stage of development but on reaching a certain threshold, where income would have grown to be able to acquire clean technologies and ensure abatement measures, pollution will begin to decline it rising income.

In addition, energy investment exerts a significant and negative influence on emission intensity, as a 100 percent increase in investment reduces emission intensity by 0.04 percent. This implies more investment in provision of clean energy reduces the proportion of population relying on biomass and other emission inducing energy sources. In the same manner, the indicator of energy losses exerts a significant and negative influence on emission intensity. It implies that as more energy is lost during the production, transmission and distribution processes; emission intensity increases. This portrays the experiences in most commodity dependence countries in Africa, as the emission from production of energy (crude oil, for instance) constitute the bulk of green-house gas (GHG) emissions. Finally, institution exerts a positive influence on emission intensity and becomes significant only at 10 percent level of significance. The positive relationship could have accentuated from the weak institutional arrangement in Africa which eventually translate into weak environmental regulations and abatement measures. The post-estimation test affirmed the robustness of the parameter estimates. The significance of AR(1) shows that the residuals are not serially correlated, the Sargan test confirms the validity of the instruments and the F-statistics indicates that the regressors are jointly statistical important in explaining the changes in emission intensity in Africa.

5. CONCLUSION AND RECOMMENDATION

The widespread impact of the different environmental crisis experienced globally had made it imperative to take urgent action towards redefining the current model of growth. Therefore, a cleaner of “greener” growth path as against dirty or “brown” growth path becomes essential resulting in emerging concepts such as green growth and green economy. This transition towards green growth or green economy or low carbon growth strategy will ensure a growth path that will be sustainable and by extension, enhance standard of living. In ensuring this transition in Africa, energy security and trade will play vital roles. A number of opportunities exist in trade and the energy sector in driving the green growth agenda. They include supporting the switch to cleaner alternative source of energy (renewables) as against fossil fuel and trading in goods that are environmentally friendly as against the current trade pattern of many African countries. Some of the countries have begun taking steps towards directing policies for the achievement of a green economy; some others have incorporated the agenda into their economic plans. However, the efforts made so far are still minimal and need to be enhanced. It is in light of this that this paper attempted to model the interaction of energy security and trade for green growth. The paper examines how trade and green economy agenda affects energy security in forty-two African countries for the period 1995 to 2014. The study captures energy security using an indicator of affordability (access) and sustainability (environmental friendliness) and situates the theoretical roots in the Environmental Kuznets Curve (EKC) Hypothesis and the Energy Ladder Hypothesis. The study adopts a dynamic panel regression technique using the collapsed instruments System GMM option. The choice of this estimation technique is premised on the inherent endogeneity challenge associated with most economic variables. The study found that the indicator of green growth and trade are important determinant of energy security in Africa. This implies that structural transformation to services oriented activities and commitment to export enhance the accessibility of clean energy services.

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