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Globalization, Governance and the Green Economy in Sub-Saharan Africa: Policy Thresholds

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Simplice A. Asongu
African Governance and Development Institute,
P.O. Box 8413 Yaoundé, Cameroon.
E-mails: asongusimplice@yahoo.com , asongus@afridev.org

Joseph Nnanna
The Development Bank of Nigeria,
The Clan Place, Plot 1386A Tigris Crescent,
Maitama, Abuja, Nigeria
E-mail: jnnanna@devbankng.com

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Simplice A. Asongu & Joseph Nnanna

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Abstract

This study assesses how globalization modulates the effect of governance on CO2 emissions in sub-Saharan African countries. The empirical evidence is based on Generalized Method of Moments. The minimum level (or negative threshold) of FDI required for it to interact with political stability and contribute towards the green economy is 45% of GDP, while 90% of GDP is the maximum level (or positive threshold) required for trade to complement "voice & accountability" in mitigating CO2 emissions. 76 % of GDP and 80 % of GDP are respectively negative trade thresholds for government effectiveness and economic governance. The corresponding negative trade thresholds for the rule of law, corruption-control and institutional governance are respectively, 230% of GDP, 63.5% of GDP and 106.5% of GDP. Actionable openness policy thresholds are provided to inform policy makers on how governance interacts with globalization to promote the green economy.

JEL Classification: C52; O38; O40; O55; P37
Keywords: CO2 emissions; Economic development; Africa

1. Introduction

How does globalization modulate the relevance of governance in carbon dioxide (CO2) emissions in Sub-Saharan Africa (SSA)? This question which motivates the present research builds on four main features in the academic and policy literature, notably: (i) the contemporary policy syndrome of CO2 emissions in the light of Sustainable Development Goals (SDGs)[1]; (ii) the importance of globalization in influencing domestic governance and by extension (iii) the relevance of domestic governance on macroeconomic outcomes such as environmental sustainability and (iv) shortcomings in the literature. These perspectives are substantiated in turn to elaborate detail.

First, consistent with recent literature, CO2 emissions are at an all time high (McGrath, 2018). This is very challenging in the light of the fact that reduction of environmental pollution is a central policy concern in the post-2015 development agenda or SDGs (Efobi, Tanankem, Orkoh, Atata, Akinyemi, & Beecroft, 2019; Asongu, le Roux & Biekpe, 2017). In accordance with McGrath (2018), CO2 emissions are increasing at a substantial rate because the overall green growth is not keeping even pace with the corresponding rise in CO2 emissions. According to the narrative, the CO2 emissions are driven by globalization and efforts at promoting the green economy are largely from domestic governments[2]. The relevance of globalization and political will are important for this research because the former is considered as a driving factor while the latter is used as a mechanism by which CO2 emissions can be reduced. These stylized factors are consistent with the problem statement of this research, notably: the role of globalization in the governance-"CO2 emissions" nexus in SSA. The articulation of SSA is motivated by a stream of literature which supports the consensus that the consequences of global warming are most detrimental in the sub-region (Apkan & Apkan, 2012; Shurig, 2015; Kifle, 2008; Asongu & Odhiambo, 2019a).

Second, in the light of the problem statement, it is reasonable to expect globalization to modulate governance for a multitude of reasons documented in the literature (Klitgaard, 1988; Lalountas, Manolas & Vavouras, 2011; Asongu, Efobi & Tchamyou, 2018a). As substantiated in subsequent paragraphs of this section, there are strong linkages globalization

[1] The notion of policy syndrome is multifaceted. While it is understood by Asongu (2017) to denote a gap in knowledge economy between two countries, the inclusive development literature has considered it as exclusive growth, notably: Asongu and Nwachukwu (2017a) and Tchamyou, Erreygers and Cassimon (2019). However, within the context of this study, environmental degradation or pollution in the perspective of CO2 emissions is considered as a policy syndrome.

[2] According to Asongu and Odhiambo (2021a), the green economy can be understood as an economy with the purpose of addressing concerns related to ecological scarcities and environmental risks with the ultimate aim to preserve the environment.

and CO2 emissions, with governance as a mechanism for the linkage. Accordingly, globalization has been documented to influence governance (Krueger, 1974; Bhagwati & Srinivasan, 1980; Bhagwati, 1982; Klitgaard, 1988; Gatti, 1999; Ades & Di Tella, 1999) and governance has also been established to affect CO2 emissions (Asongu & Odhiambo, 2021b). Hence, it is reasonable to expect globalization to modulate the incidence of governance on CO2 emissions.

Third, building on the substantially documented relevance of good governance in development outcomes, there is a growing body of literature supporting the perspective that political will and good governance are important in tackling the issue of environmental pollution, especially in the light of SDGs. Some studies within this strand of literature include: Odhiambo (2009a, 2009b, 2010), Efobi *et al*. (2019), Asongu, le Roux and Biekpe (2018b), Jarrett (2017), Asongu (2018a), Akinyemi, Efobi, Asongu and Osabuohien (2018), Anyangwe (2014), Akinyemi, Alege, Osabuohien and Ogundipe (2015), Jones (2003), Hongwu (2013), Afful-Koomson (2012), Chemutai (2009) and Odhiambo (2014a, 2014b). Unfortunately, the attendant literature has failed to assess the role of globalization in modulating the effect of governance on CO2 emissions.

Fourth, two main streams characterize the body of literature on linkages between environmental degradation, energy consumption and other macroeconomic variables. The first stream embodies studies articulating connections between economic prosperity and environmental pollution whereas the second stream is concerned with the nexus between consumption of energy and economic development. Research in the second strand can be sub-divided into two principal categories: (i) inquiries that are oriented towards bivariate linkages between energy use and economic development and (ii) research focusing on trivariate connections between the "use of energy", economic development and environment pollution. Some examples of studies in the first category are: Jumbe (2004), Ang (2007), Odhiambo (2009a, 2009b), Apergis and Payne (2009), Menyah and Wolde-Rufael (2010), Begum, Sohag, Abdullah and Jaafar (2015), Ozturk and Acaravci, (2010), Bölük and Mehmet (2015) and Begum *et al*., (2015). Some examples of research in the second category include: Mehrara (2007), Olusegun (2008), Akinlo (2008) and Esso (2010).

In the second strand of the literature, the concern of researchers pertains exclusively to testing the Environmental Kuznets Curve (EKC) hypothesis. The EKC hypothesis is a postulation that there is a non-linear nexus between environmental standards and income

levels in the long run. Some example of studies in this strand are: He and Richard (2010), Diao, Zeng, Tam and Tam (2009) and Akbostanci, Turut-Asi and Tunc (2009).

The positioning of this study is closest to the second strand of the literature in the perspective that, it assesses the relevance of macroeconomic variables in environmental degradation. However, contrary to the underlying literature which is simply based on confirming or rejecting the EKC hypothesis, the innovations of this study are twofold. On the one hand, the research argues that it is not enough to establish linkages between two variables to confirm or reject the EKC. Accordingly, policy makers should be more interested in: (i) how policy instruments influence environmental degradation and (ii) by what mechanisms. This research incorporates the underlying critique by adopting globalization, governance and CO2 emissions respectively, as moderating instruments, policy channels and the policy syndrome of environmental degradation. On the other hand, it is also relevant for policy makers to be informed on specific policy thresholds at which the policy instruments interact with the mechanisms to influence the policy syndrome. To this end, this research also goes a step further by computing globalization policy thresholds at which governance either reduces or increases CO2 emissions. These policy thresholds are actionable measures that can be directly implemented by sampled countries in order to target specific outcomes pertaining to the green economy.

In order to increase room for policy implications, the six governance mechanisms (political stability/no violence, "voice & accountability", government effectiveness, regulation quality, rule of law and corruption-control) are bundled to produce four more governance channels (i.e. political, economic, institutional and general governance dynamics). The interest of bundling and unbundling governance indicators builds on evolutions in the conception, measurement and employment of governance terms in scientific scholarly reporting. For instance, the term institutional governance is not appropriate to be employed unless it is a composite measurement from corruption-control and the rule of law. Hence, it is in the interest of avoiding conceptual conflation that the governance indicators are further bundled by means of principal component analysis in order for scholarly reporting to be consistent with the conception and definition of governance dynamics. An example of a study in the literature in which the underlying conceptual conflation is apparent is Kangoye (2013). Accordingly, the study has used the term "general governance" in the narratives when corruption is employed as the governance dynamic. In the light of this critique and attendant example, this research argues that the term "general governance" can exclusively be

employed when it is appreciated by indicators that reflect the institutional governance, economic governance and political governance.

The intuition motivating the connections between variables being investigated in this study is simple to follow. The relevance of globalization in governance outcomes has been substantially documented in the theoretical and empirical literature (Krueger, 1974; Bhagwati & Srinivasan, 1980; Bhagwati, 1982; Klitgaard, 1988; Gatti, 1999; Ades & Di Tella, 1999; Wei, 2000; Bonaglia, Braga de Macedo, Bussolo, 2001; Lalountas, Manolas & Vavouras 2011; Asongu, 2014). Moreover, the importance of governance in CO2 emission has also been discussed in the preceding paragraphs. By building on the established evidence in the literature, this research is consistent with the stream of literature arguing that applied econometrics should not be exclusively limited to the acceptance and rejection of existing models (Narayan, Mishra & Narayan, 2011; Asongu & Nwachukwu, 2016a). Hence, it is a useful scientific activity to build on established theoretical and empirical evidences in order to investigate linkages that are relevant to environmental sustainability in the post-2015 development agenda.

The rest of the research is structured as follows. The data and methodology are covered in section 2. Section 3 presents and discusses the empirical findings while section 4 concludes with implications and future research directions.

2. Data and methodology

2.1 Data

This study focuses on 44 countries in SSA with data for the period 2000-2012[3]. The data come from three main sources, notably: (i) six governance dynamics are obtained from World Governance Indicators of the World Bank (political stability/no violence, "voice & accountability", government effectiveness, regulation quality, corruption-control and the rule of law); (ii) the outcome variable (i.e. CO2 emissions per capita), globalization variables (trade openness and financial openness) and control variables (gross domestic product growth, population growth and education) and (iii) the composite governance indicators (i.e. political, economic, institutional and general governance) are derived from principal component

[3] The 44 countries are: "Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo Democratic. Republic., Congo Republic, Cote d'Ivoire, Djibouti, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome & Principe, Senegal, Seychelles, Sierra Leone, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda and Zambia".

analysis (PCA) covered in Section 2.2.1. The geographical and temporal scopes of the study are contingent on data availability constraints at the time of the study.

Borrowing from recent environmental pollution literature (Asongu, 2018a, 2018b), CO2 emission per capita is employed as the indicator for environmental degradation and the globalization indicators are proxied by trade (imports + exports) and net foreign direct investment (FDI) inflows. The engaged six governance dynamics are primarily from Kaufmann, Kraay and Mastruzzi (2010). According to the attendant literature: "*The first concept is about the process by which those in authority are selected and replaced (Political Governance): voice and accountability and political stability. The second has to do with the capacity of government to formulate and implement policies, and to deliver services (Economic Governance): regulatory quality and government effectiveness. The last, but by no means least, regards the respect for citizens and the state of institutions that govern the interactions among them (Institutional Governance): rule of law and control of corruption*" (Andres, Asongu & Amavilah, 2015, p. 1041). These governance indicators are increasingly used in contemporary development literature, notably by: Oluwatobi, Efobi, Olurinola and Alege (2015), Ajide and Raheem (2016a, 2016b) and Asongu and Nwachukwu (2017b).

Still in accordance with the attendant literature which has employed CO2 emission per capita as the outcome variable, three principal control variables are adopted in view of accounting for variable omission bias, namely: education, population growth and gross domestic product (GDP) growth. The three control variables are expected to bear negatively on the outcome variable, contingent on the equitable distribution of the fruits of economic prosperity across the population. Whereas the relationship between the first control variable and the outcome variable is intuitive, the relevance of population growth and economic growth is contingent on how the average population participates in the production and consumption processes in the economy. For instance, if economic growth is associated with more equitable distribution of fruits of economic prosperity across the population, the average citizen can contribute more towards the production and consumption processes in the domestic economy and by extension participate in the emission of green house gases. Conversely, if the fruits of economic prosperity are not equitably distributed, the average person is likely to contribute less in the corresponding consumption and production processes.

The underlying explanation on economic growth also extends to population growth in the perspective that, the poor account for more of the population growth in African countries because, the rich have preferred to quality of children to the quantity of children (Asongu,

2013). Hence the burden of population growth does not necessarily translate into enhanced possibilities of participating more towards green house gas emissions if the fruits of economic growth are largely retained by wealthy factions of the population. Unfortunately, in spite of more than two decades of growth resurgence in SSA, the number of people living in extreme poverty has been rising. Accordingly, close to half of countries in the sub-region did not achieve the millennium development goal (MDG) extreme poverty target (Tchamyou, 2019, 2020; Tchamyou *et al*., 2019).

The research limits variables in the conditioning information set to three because from a pilot empirical analysis, taking on board more than three control variables produces the proliferation of instruments which constraints the estimated models to fail post-estimation diagnostic tests, even when the specification exercises are tailored such that the instruments are collapsed in the processes. It is not uncommon in the application of the Generalised Method of Moments for variables in the conditioning information to be three or less than three. Examples from the empirical literature include: (i) Bruno, De Bonis and Silvestrini (2012) who have used two control variables and (iii) Asongu and Nwachukwu (2017c) and Osabuohien and Efobi (2013) who have not used control variables. The definitions and sources of the variables are provided in Appendix 1 while the summary statistics is disclosed in Appendix 2. Appendix 3 presents the correlation matrix.

2.2 Methodology

2.2.1 Principal Component Analysis (PCA)

In the light of the motivation of the study (covered in the introduction) and complementary discourse in the data section, the PCA technique is used to bundle the six governance variables into four composite governance dynamics. Examples of recent economic development studies on Africa that have employed the PCA technique to bundle governance variables in order to enhance room for policy implications are: Tchamyou (2017) and Asongu, le Roux, Nwachukwu and Pyke (2019).

The PCA consists to reducing a set of variables that are highly correlated into a smaller set of uncorrelated indicators called principal components (PCs). Building on this technique: (i) “voice & accountability” and political stability/no violence are reduced to political governance; (ii) regulation quality and government effectiveness are reduced to economic governance; (iii) the rule of law and corruption-control are reduced to institutional governance and (iv) “voice & accountability”, political stability/no violence, regulation

quality, government effectiveness, the rule of law and corruption-control are reduced to general governance.

The Kaiser (1974) and Jolliffe (2002) rule of thumb is used to retain the composite indicators. The rule of thumb suggests that only PCs that are higher than 1 or the mean and which reflect about 70% of variation in the constituent indicators should be retained. Table 1 discloses the PCA findings. In line with the criteria for retaining common factors in the various governance dimensions: general governance (*G.gov*), institutional governance (*Instgov*), economic governance (*Ecogov*) and political governance (*Polgov*) respectively, reflect variations (eigenvalues) of 81.50 %, 93.0 %, 93.9 % and 83.5 % (4.892, 1.861, 1.878 and 1.671).

Table 1: Principal Component Analysis (PCA) for Governance (Gov)

Principal Components	Component Matrix (Loadings)						Proportion	Cumulative Proportion	Eigen Value
	VA	PS	RQ	GE	RL	CC			
First PC (*G.Gov*)	0.395	0.372	0.411	0.426	0.439	0.404	0.815	0.815	4.892
Second PC	-0.037	0.873	-0.357	-0.303	0.037	-0.124	0.067	0.883	0.407
Third PC	0.747	-0.035	0.157	-0.131	-0.086	-0.626	0.052	0.935	0.314
First PC (*Polgov*)	0.707	0.707	---	---	---	---	0.835	0.835	1.671
Second PC	-0.707	0.707	---	---	---	---	0.164	1.000	0.328
First PC (*Ecogov*)	---	---	0.707	0.707	---	---	0.939	0.939	1.878
Second PC	---	---	-0.707	0.707	---	---	0.060	1.000	0.121
First PC (*Instgov*)	---	---	---	---	0.707	0.707	0.930	0.930	1.861
Second PC	---	---	---	---	-0.707	0.707	0.069	1.000	0.138

P.C: Principal Component. VA: Voice & Accountability. RL: Rule of Law. R.Q: Regulation Quality. GE: Government Effectiveness. PS: Political Stability. CC: Control of Corruption. G.Gov (General Governance): First PC of VA, PS, RQ, GE, RL & CC. Polgov (Political Governance): First PC of VA & PS. Econgov (Economic Governance): First PC of RQ & GE. Instgov (Institutional Governance): First PC of RL & CC.

2.2.2 GMM: specification, identification and exclusion restrictions

In the light of the growing application of the Generalised Method of Moments (GMM) as empirical strategy in development economics, this research adopts the estimation technique because of four principal motivations documented in the attendant literature (Tchamyou, 2019, 2020). The first motivation is that the environmental degradation variable is characterized by persistence because the correlation between its level and first lag values is greater than 0.800, which is the established rule of thumb for appreciating persistence in a variable (Tchamyou *et al.*, 2019). The second motivation is the fulfillment of a baseline condition which requires that the number of periods within a cross section should be lower than the corresponding number of cross sections. Third, in the empirical exercise, cross-

country variations are factored-in because the data structure is panel. Fourth, the critical concern of endogeneity is tackled on two fronts: (i) simultaneity or reverse causality is taken on board by means of an instrumentation process and (ii) the unobserved heterogeneity is also controlled with the help of time invariant variables.

The empirical framework of Roodman (2009a, 2009b) is adopted in this study because of its advantages compared the traditional difference GMM approach (i.e. of Arellano & Bover, 1995), that has comparatively less efficient estimates. The updated approach also limits the proliferation of instruments. Asongu and Nwachukwu, (2016b), Tchamyou *et al*. (2019) and Boateng, Asongu, Akamavi and Tchamyou (2018) have used the same arguments.

The following equations in level (1) and first difference (2) summarize the standard *system* GMM estimation procedure.

$$C_{i,t} = \sigma_0 + \sigma_1 C_{i,t-\tau} + \sigma_2 O_{i,t} + \sigma_3 G_{i,t} + \sigma_4 OG_{i,t} + \sum_{h=1}^{3} \delta_h W_{h,i,t-\tau} + \eta_i + \xi_t + \varepsilon_{i,t} \quad (1)$$

$$\begin{aligned} C_{i,t} - C_{i,t-\tau} = {} & \sigma_1 (C_{i,t-\tau} - C_{i,t-2\tau}) + \sigma_2 (O_{i,t} - O_{i,t-\tau}) + \sigma_3 (G_{i,t} - G_{i,t-\tau}) + \sigma_4 (OG_{i,t} - OG_{i,t-\tau}) \\ & + \sum_{h=1}^{3} \delta_h (W_{h,i,t-\tau} - W_{h,i,t-2\tau}) + (\xi_t - \xi_{t-\tau}) + (\varepsilon_{i,t} - \varepsilon_{i,t-\tau}) \end{aligned} \quad (2)$$

where, $C_{i,t}$ is the CO emissions variable of country i in period t, σ_0 is a constant, O represents openness (trade openness and financial openness), G consists of governance dynamics (political stability, voice & accountability, government effectiveness, regulation quality, rule of law, corruption-control, political governance, economic governance, institutional governance and general governance), OG denotes an interaction between an openness variable and a governance dynamic ("political stability" × "openness", "voice & accountability" × "openness", "government effectiveness" × "openness", "regulation quality" × "openness", "corruption-control" × "openness", "rule of law" × "openness", "political governance" × "openness", "economic governance" × "openness", "institutional governance" × "openness" and "general governance" × "openness"), W is the vector of control variables (*GDP growth, population growth* and *education*), τ represents the coefficient of auto-regression which is one within the framework of this study because a year lag is enough to capture past information, ξ_t is the time-specific constant, η_i is the country-specific effect and $\varepsilon_{i,t}$ is the error term.

2.2.3 Identification and exclusion restrictions

Cognizant of the process of specification discussed in the previous section, this study is in accordance with the contemporary research in its strategy of identification and assumption of exclusion restrictions, notably: Asongu and Nwachukwu (2016c), Tchamyou and Asongu (2017), Meniago and Asongu (2018), Tchamyou *et al*. (2019) and Boateng *et al*. (2018). The identification approach is such that the time invariant variables are defined as strictly exogenous whereas the endogenous explaining indicators are acknowledged to be explanatory variables. Such an approach to identification is consistent with Roodman (2009b) who has argued that it is not feasible for the identified strictly exogenous variables to the exogenous after a first difference[4].

In line with the strategy of identification, the corresponding exclusion restriction assumption is examined with the Difference in Hansen Test (DHT). The null hypothesis of this test should not be rejected in order for the outcome variable to be elucidated exclusively via the predetermined or endogenous explaining variables. Hence, this null hypothesis is the position that the instruments are valid. This procedure for assessing and validating the adopted identification approach is not dissimilar to the standard instrumental variable (IV) approach from which, failure to reject the null hypothesis of the Sargan test implies that the instruments elucidate the outcome indicator exclusively through the identified mechanisms captured in the endogenous explaining variables, notably: Beck, Demirgüç-Kunt and Levine (2003) and Asongu and Nwachukwu (2016d).

3. Presentation of results

3.1 Empirical results

Table 2, Table 3, Table 4 and Table 5 disclose the empirical results on linkages between globalization, governance and CO2 emissions. Table 2, Table 3, Table 4 and Table 5 respectively focus on political governance, economic governance, institutional governance and general governance. Tables 2-4 are respectively divided into three categories: the first-two focus on components the governance variables whereas the last shows findings from the composite governance variable derived from PCA. Each category is characterized by both trade- and FDI-oriented specifications.

[4] Hence, the procedure for treating *ivstyle* (years) is 'iv (years, eq(diff))' whereas the *gmmstyle* is employed for predetermined variables.

In order to assess the overall validity of estimated models, four principal information criteria are use to examine the validity of post-estimation diagnostics[5]. In the light of these criteria, the estimated models are overwhelmingly valid with a few exceptions: (i) the last specification of Table 4 and (ii) the third and fifth specifications of Table 5. These specifications are not valid because the alternative hypothesis of the Hansen test is not rejected. The Hansen test is more relevant than the Sargan test because it is robust, though weakened by the proliferation of instruments. Hence, given that the Sargan test is not robust, but not weakened by the proliferation of instruments, a means of dealing with the conflict is to give priority to the Hansen test and limit the proliferation of instruments by ensuring that the number of instruments is less than the corresponding number of countries in each specification.

In order to investigate the total impact of the role of globalization in moderating the effect of governance on CO2 emissions, net impacts are calculated. The calculation of these net impacts consists of engaging the unconditional and conditional impacts of governance variables. For example, in the third column of Table 2, the net effect of financial openness in modulating the effect of political stability on CO2 emissions is 0.0396 ([-0.001× 5.381] + [0.045]). In the calculation, the average value of FDI is 5.381, the unconditional impact of political stability is 0.045 and conditional effect from the interaction between political stability and FDI is -0.001.

The following findings can be established from Tables 2-5. First, in Table 2: (i) FDI modulates political stability to induce a positive net effect on CO2 emissions and (ii) trade moderates "voice & accountability" to have a negative net effect on CO2 emissions. Second, in Table 3, trade moderates government effectiveness and economic governance to respectively have negative and positive net effects on CO2 emissions. Third, in Table 4, trade modulates the rule of law and institutional governance to bear positive net effects on CO2 emissions while it moderates corruption-control to have a negative net effect on CO2 emissions. Fourth, the significant control variables have the expected signs.

[5] "*First, the null hypothesis of the second-order Arellano and Bond autocorrelation test (AR (2)) in difference for the absence of autocorrelation in the residuals should not be rejected. Second the Sargan and Hansen over-identification restrictions (OIR) tests should not be significant because their null hypotheses are the positions that instruments are valid or not correlated with the error terms. In essence, while the Sargan OIR test is not robust but not weakened by instruments, the Hansen OIR is robust but weakened by instruments. In order to restrict identification or limit the proliferation of instruments, we have ensured that instruments are lower than the number of cross-sections in most specifications. Third, the Difference in Hansen Test (DHT) for exogeneity of instruments is also employed to assess the validity of results from the Hansen OIR test. Fourth, a Fisher test for the joint validity of estimated coefficients is also provided*" (Asongu & De Moor, 2017, p.200).

Table 2: Political governance, globalization and environmental degradation

	Dependent variable: CO2 emissions per capita					
	Political Stability (PS)		Voice & Accountability (VA)		Political Governance (Polgov)	
	Trade G.	Financial G.	Trade G.	Financial G.	Trade G.	Financial G.
CO2 emissions (-1)	**0.929*** (0.000)**	**0.901*** (0.000)**	**0.933*** (0.000)**	**0.891*** (0.000)**	**0.935*** (0.000)**	**0.885*** (0.000)**
Political Stability (PS)	0.049 (0.146)	**0.045** (0.049)**	---	---	---	---
Voice & Accountability (VA)	---	---	**-0.090** (0.027)**	0.113 (0.176)	---	---
Political Governance (Polgov)	---	---	---	---	0.009 (0.753)	**0.098** (0.016)**
Trade Globalization (Trade)	**-0.001** (0.023)**	---	-0.0001 (0.787)	---	**-0.0008* (0.057)**	---
Financial Globalization (Fin)	---	**-0.002*** (0.005)**	---	0.0007 (0.709)	---	0.0002 (0.768)
PS ×Trade	-0.0005 (0.133)	---	---	---	---	---
VA × Trade	---	---	**0.001** (0.016)**	---	---	---
Polgov × Trade	---	---	---	---	-0.0004 (0.205)	---
PS ×Fin	---	**-0.001* (0.078)**	---	---	---	---
VA × Fin	---	---	---	-0.0001 (0.928)	---	---
Polgov × Fin	---	---	---	---	---	-0.0004 (0.471)
GDP growth	-0.001 (0.122)	**-0.002** (0.037)**	-0.001 (0.239)	-0.0003 (0.711)	-0.0008 (0.429)	**-0.002** (0.013)**
Population growth	**-0.107*** (0.000)**	**-0.120*** (0.000)**	**-0.090*** (0.000)**	**-0.121*** (0.000)**	**-0.097*** (0.000)**	**-0.123*** (0.000)**
Education	**0.002** (0.022)**	-0.0008 (0.489)	0.002 (0.169)	0.001 (0.609)	.0009 (0.557)	0.001 (0.573)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Net effects	na	0.0396	-0.0132	na	na	na
Thresholds		45	90			
AR(1)	**(0.125)**	**(0.133)**	**(0.131)**	**(0.131)**	**(0.124)**	**(0.126)**
AR(2)	**(0.155)**	**(0.158)**	**(0.166)**	**(0.155)**	**(0.163)**	**(0.146)**
Sargan OIR	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Hansen OIR	**(0.534)**	**(0.274)**	**(0.689)**	**(0.839)**	**(0.712)**	**(0.404)**
DHT for instruments						
(a)Instruments in levels						
H excluding group	**(0.222)**	(0.025)	**(0.114)**	**(0.131)**	**(0.173)**	(0.045)
Dif(null, H=exogenous)	**(0.621)**	**(0.662)**	**(0.873)**	**(0.959)**	**(0.840)**	**(0.738)**
(b) IV (years, eq(diff))						
H excluding group	**(0.537)**	**(0.246)**	**(0.276)**	**(0.585)**	**(0.666)**	**(0.409)**
Dif(null, H=exogenous)	**(0.453)**	**(0.359)**	**(0.886)**	**(0.834)**	**(0.587)**	**(0.389)**
Fisher	**18321.75***	**10293.13***	**29383.52***	**3120.04***	**33618.88***	**4955.03***
Instruments	36	36	36	36	36	36
Countries	43	43	43	43	43	43
Observations	294	295	294	295	294	295

*, **, ***: significance levels of 10%, 5% and 1% respectively. *DHT*: Difference in Hansen Test for Exogeneity of Instruments' Subsets. Dif: Difference. *OIR*: Over-identifying Restrictions Test. The significance of bold values is twofold. 1) The significance of estimated coefficients, Hausman test and the Fisher statistics. 2) The failure to reject the null hypotheses of: a) no autocorrelation in the *AR(1)*and*AR(2)* tests and; b) the validity of the instruments in the Sargan *OIR* test. Na: not applicable because at least one estimated coefficient needed for the computation of net effects is not significant. Constants are involved in the regressions. The mean value of trade openness is 76.759 while the mean value of financial openness is 5.381.

Table 3: Economic governance, globalization and environmental degradation

	Dependent variable: CO2 emissions per capita					
	Regulation Quality (RQ)		Government Effectiveness (GE)		Economic Governance (Ecogov)	
	Trade G.	Financial G.	Trade G.	Financial G.	Trade G.	Financial G.
CO2 emissions (-1)	**0.910*** (0.000)**	**0.879*** (0.000)**	**0.937*** (0.000)**	**0.919*** (0.000)**	**0.918*** (0.000)**	**0.899*** (0.000)**
Regulation Quality (RQ)	**0.140** (0.049)**	**0.225*** (0.001)**	---	---	---	---
Government Effectiveness (GE)	---	---	**0.076* (0.061)**	0.014 (0.591)	---	---
Economic Governance (Ecogov)	---	---	---	---	**0.056* (0.056)**	**0.060*** (0.003)**
Trade Globalization (Trade)	**-0.001** (0.015)**	---	**-0.003*** (0.000)**	---	**-0.001*** (0.000)**	---
Financial Globalization (Fin)	---	**-0.002* (0.061)**	---	0.0004 (0.785)	---	**-0.001** (0.026)**
RQ ×Trade	-0.001 (0.157)	---	---	---	---	---
GE × Trade	---	---	**-0.001*** (0.003)**	---	---	---
Ecogov × Trade	---	---	---	---	**-0.0007*** (0.040)**	---
RQ ×Fin	---	-0.001 (0.288)	---	---	---	---
GE × Fin	---	---	---	0.0008 (0.570)	---	---
Ecogov × Fin	---	---	---	---	---	-0.0009 (0.254)
GDP growth	-0.0004 (0.677)	**-0.001* (0.067)**	-0.001 (0.373)	**-0.002** (0.021)**	-0.001 (0.278)	-0.002 (0.002)
Population growth	**-0.110*** (0.000)**	**-0.105*** (0.000)**	**-0.105*** (0.000)**	**-0.086*** (0.000)**	**-0.108*** (0.000)**	**-0.090*** (0.000)**
Education	-0.0005 (0.757)	-0.001 (0.165)	-0.0005 (0.705)	-0.0009 (0.363)	-0.001 (0.277)	-0.001 (0.197)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Net effects	na	na	-0.0007	na	0.0022	na
Thresholds			76		80	
AR(1)	**(0.129)**	**(0.146)**	**(0.125)**	**(0.128)**	**(0.123)**	**(0.130)**
AR(2)	**(0.158)**	**(0.153)**	**(0.162)**	**(0.165)**	**(0.160)**	**(0.156)**
Sargan OIR	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Hansen OIR	**(0.588)**	**(0.264)**	**(0.356)**	**(0.323)**	**(0.430)**	**(0.138)**
DHT for instruments						
(a)Instruments in levels						
H excluding group	(0.033)	(0.075)	**(0.158)**	**(0.108)**	**(0.215)**	(0.088)
Dif(null, H=exogenous)	**(0.932)**	**(0.464)**	**(0.470)**	**(0.489)**	**(0.509)**	**(0.244)**
(b) IV (years, eq(diff))						
H excluding group	**(0.212)**	**(0.339)**	(0.060)	(0.028)	**(0.120)**	(0.069)
Dif(null, H=exogenous)	**(0.851)**	**(0.265)**	**(0.890)**	**(0.973)**	**(0.816)**	**(0.414)**
Fisher	**75860.65***	**10303.64***	**18747.56***	**69032.16***	**105612***	**21962.50***
Instruments	36	36	36	36	36	36
Countries	43	43	43	43	43	43
Observations	294	295	294	295	294	295

*, **, ***: significance levels of 10%, 5% and 1% respectively. *DHT*: Difference in Hansen Test for Exogeneity of Instruments' Subsets. Dif: Difference. *OIR*: Over-identifying Restrictions Test. The significance of bold values is twofold. 1) The significance of estimated coefficients, Hausman test and the Fisher statistics. 2) The failure to reject the null hypotheses of: a) no autocorrelation in the *AR(1)*and*AR(2)* tests and; b) the validity of the instruments in the Sargan *OIR* test. Na: not applicable because at least one estimated coefficient needed for the computation of net effects is not significant. Constants are involved in the regressions. The mean value of trade openness is 76.759 while the mean value of financial openness is 5.381.

Table 4: Institutional governance, globalization and environmental degradation

	Dependent variable: CO2 emissions per capita					
	Rule of Law (RL)		Corruption Control (CC)		Institutional Governance (Instgov)	
	Trade G.	Financial G.	Trade G.	Financial G.	Trade G.	Financial G.
CO2 emissions (-1)	**0.896*** (0.000)**	**0.845*** (0.000)**	**0.927*** (0.000)**	**0.930*** (0.000)**	**0.915*** (0.000)**	**0.921*** (0.000)**
Rule of Law (RL)	**0.230** (0.011)**	**0.258*** (0.000)**	---	---	---	---
Corruption Control (CC)	---	---	**0.127** (0.026)**	-0.004 (0.841)	---	---
Institutional Governance (Instgov)	---	---	---	---	**0.085** (0.018)**	**0.019* (0.082)**
Trade Globalization (Trade)	**-0.002** (0.019)**	---	**-0.002*** (0.000)**	---	**-0.001** (0.010)**	---
Financial Globalization (Fin)	---	-0.002 (0.249)	---	**-0.002* (0.081)**	---	-0.0007 (0.211)
RL × Trade	**-0.001* (0.064)**	---	---	---	---	---
CC × Trade	---	---	**-0.002** (0.012)**	---	---	---
Instgov × Trade	---	---	---	---	**-0.0008** (0.034)**	---
RL × Fin	---	-0.001 (0.485)	---	---	---	---
CC × Fin	---	---	---	-0.001 (0.268)	---	---
Instgov × Fin	---	---	---	---	---	-0.001 (0.165)
GDP growth	-0.0005 (0.570)	-0.0006 (0.462)	**-0.002** (0.022)**	**-0.002** (0.010)**	**-0.002** (0.030)**	**-0.003*** (0.001)**
Population growth	**-0.101*** (0.000)**	**-0.129*** (0.000)**	**-0.133*** (0.000)**	**-0.101*** (0.000)**	**-0.111*** (0.000)**	**-0.086*** (0.000)**
Education	**-0.003** (0.027)**	**-0.004** (0.013)**	-0.0008 (0.531)	0.0009 (0.280)	**-0.002* (0.078)**	-0.0006 (0.577)
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Net effects	0.1532	na	-0.0265	na	0.0788	na
Thresholds	230		63.5		106.25	
AR(1)	**(0.121)**	**(0.131)**	**(0.130)**	**(0.132)**	**(0.122)**	**(0.124)**
AR(2)	**(0.158)**	**(0.153)**	**(0.153)**	**(0.164)**	**(0.153)**	**(0.161)**
Sargan OIR	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Hansen OIR	**(0.541)**	**(0389)**	**(0.448)**	**(0.291)**	**(0.103)**	(0.077)
DHT for instruments						
(a)Instruments in levels						
H excluding group	**(0.149)**	(0.027)	(0.054)	(0.026)	**(0.151)**	(0.022)
Dif(null, H=exogenous)	**(0.694)**	**(0.800)**	**(0.755)**	**(0.681)**	**(0.143)**	**(0.265)**
(b) IV (years, eq(diff))						
H excluding group	**(0.168)**	**(0.489)**	**(0.326)**	**(0.134)**	**(0.506)**	**(0.126)**
Dif(null, H=exogenous)	**(0.859)**	**(0.315)**	**(0.523)**	**(0.565)**	(0.051)	**(0.150)**
Fisher	**23428.75***	**8807.31***	**19844.12***	**16498.84***	**28062.78***	**16555.85***
Instruments	36	36	36	36	36	36
Countries	43	43	43	43	43	43
Observations	294	295	294	295	294	295

*, **, ***: significance levels of 10%, 5% and 1% respectively. *DHT*: Difference in Hansen Test for Exogeneity of Instruments' Subsets. Dif: Difference. *OIR*: Over-identifying Restrictions Test. The significance of bold values is twofold. 1) The significance of estimated coefficients, Hausman test and the Fisher statistics. 2) The failure to reject the null hypotheses of: a) no autocorrelation in the *AR(1)*and*AR(2)* tests and; b) the validity of the instruments in the Sargan *OIR* test. Na: not applicable because at least one estimated coefficient needed for the computation of net effects is not significant. Constants are involved in the regressions. The mean value of trade openness is 76.759 while the mean value of financial openness is 5.381.

Table 5: General governance, globalization and environmental degradation

	Dependent variable: CO2 emissions per capita			
	Trade G.		Financial G.	
CO2 emissions (-1)	**0.880*** **	**0.920*** **	**0.949*** **	**0.892*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**
General Governance (Ggov)	-0.001	**0.054*** **	**-0.039** **	**0.051*** **
	(0.926)	**(0.008)**	**(0.026)**	**(0.000)**
Trade Globalization (Trade)	**-0.001***	**-0.001*** **	---	---
	(0.096)	**(0.000)**		
Financial Globalization (Fin)	---	---	-0.0005	**-0.001***
			(0.561)	**(0.071)**
Ggov ×Trade	0.0001	**-0.0005** **	---	---
	(0.645)	**(0.018)**		
Ggov × Fin	---	---	0.0003	-0.0005
			(0.325)	(0.269)
GDP growth	---	**-0.002** **	---	**-0.003*** **
		(0.024)		**(0.000)**
Population growth	---	**-0.106*** **	---	**-0.098*** **
		(0.000)		**(0.000)**
Education	---	-0.002	---	-0.001
		(0.146)		(0.119)
Time Effects	Yes	Yes	Yes	Yes
Net effects	na	nsa	na	na
Thresholds				
AR(1)	(0.087)	(0.120)	(0.096)	(0.126)
AR(2)	**(0.702)**	**(0.155)**	**(0.736)**	**(0.149)**
Sargan OIR	(0.000)	(0.000)	(0.000)	(0.000)
Hansen OIR	**(0.424)**	(0.073)	**(0.200)**	(0.059)
DHT for instruments				
(a)Instruments in levels				
H excluding group	---	**(0.203)**	---	(0.036)
Dif(null, H=exogenous)	**(0.753)**	(0.087)	(0.432)	**(0.168)**
(b) IV (years, eq(diff))				
H excluding group	---	**(0.354)**	---	(0.084)
Dif(null, H=exogenous)	---	(0.051)	---	**(0.152)**
Fisher	**1248.47*** **	**43461.27*** **	**5675.19*** **	**16087.23*** **
Instruments	25	36	25	36
Countries	44	43	44	43
Observations	404	294	415	295

*, **, ***: significance levels of 10%, 5% and 1% respectively. *DHT*: Difference in Hansen Test for Exogeneity of Instruments' Subsets. Dif: Difference. *OIR*: Over-identifying Restrictions Test. The significance of bold values is twofold. 1) The significance of estimated coefficients, Hausman test and the Fisher statistics. 2) The failure to reject the null hypotheses of: a) no autocorrelation in the *AR(1)*and*AR(2)* tests and; b) the validity of the instruments in the Sargan *OIR* test. Na: not applicable because at least one estimated coefficient needed for the computation of net effects is not significant . Constants are involved in the regressions. The mean value of trade openness is 76.759 while the mean value of financial openness is 5.381

3.2 Extended analysis with thresholds

Cognizant of the motivation of this study, the empirical analysis is extended by establishing specific thresholds at which globalization modulates governance to either positively or negatively affect CO2 emissions. In this light, a positive threshold is a critical mass at which the overall moderating effect changes from negative to positive whereas a negative threshold is a critical mass at which the overall modulating impact changes from positive to negative.

The underlying conception of threshold is consistent with contemporary development literature, notably: Batuo (2015) and Asongu and Odhiambo (2019b, 2019c) on inflexion points for economic ramifications and Ashraf and Galor (2013) on the basis for economic interactions that reflect inverted U-shapes and U-shapes.

Given the findings established in Tables 2-5, positive thresholds are computable where marginal or conditional effects are positive while negative thresholds are also computable when marginal impacts are negative. For instance, in the third column of Table 2, the corresponding negative threshold is 45 (0.045/0.001). Hence, when net FDI inflows is 45(% of GDP), the unconditional positive effect of political stability on CO2 emissions is completely nullified ([-0.001× 45] + [0.045] =0). Hence the minimum level of FDI required for it to interact with political stability and contribute towards the green economy by dampening CO2 emissions is 45 (% of GDP) of net FDI inflows. With the same computational analogy, in the fourth column of Table 2, the positive threshold corresponding to the interaction between "voice & accountability" and trade is 90 (0.090/0.001) % of GDP. Hence, a 90% of GDP is the maximum required for trade to complement "voice & accountability" in mitigating CO2 emissions. Accordingly, owing to the positive marginal effect, above this positive threshold, the interaction between trade and "voice & accountability" produces positive effects on CO2 emissions. It follows that, in the light of the outcome variable which is a policy syndrome, positive thresholds (related to positive marginal effects) are maximum points that should not be surpassed in order for the underlying interactions to promote the green economy. Conversely, negative thresholds (associated with negative marginal effects) are minimum points that should be surpassed in order for the underlying interactions to enhance the green economy.

In the light of the above clarifications, in Table 3, 76 (% of GDP) and 80 (% of GDP) are respectively negative trade thresholds for government effectiveness and economic governance. In Table 4, the corresponding negative thresholds for the rule of law, corruption-control and institutional governance are respectively, 230 (% of GDP), 63.5 (% of GDP) and 106.5 (% of GDP). The established thresholds make economic sense and are actionable policy measures because they are within the range of trade openness (20.964 to 209.874) disclosed in the summary statistics. The FDI threshold from Table 2 is also within policy range.

4. Concluding implications, caveats and future research directions

The purpose of this study is to assess linkages between globalization, governance and CO2 emissions in 44 SSA countries for the period 2002-2012. The EKC hypotheses are tested and net effects from interactions as well as policy thresholds are also established. Globalization is appreciated from trade (imports + exports) and net foreign direct investment (FDI) inflows. The empirical evidence is based on Generalized Method of Moments. The following main findings are established.

First, concerning the net effects: (i) FDI modulates political stability to induce a positive net effect on CO2 emissions and (ii) trade moderates "voice & accountability" to have a negative effect on CO2 emissions; (iii) trade moderates government effectiveness and economic governance to respectively have negative and positive net effects on CO2 emissions and (iv) trade modulates the rule of law and institutional governance to bear positive net effects on CO2 emissions while it moderates corruption-control to have a negative net effect on CO2 emissions.

Second, the minimum level (or negative threshold) of FDI required for it to interact with political stability and contribute towards the green economy by dampening CO2 emissions is 45(% of GDP), while 90% of GDP is the maximum level (or positive threshold) required for the trade to complement "voice & accountability" in mitigating CO2 emissions. 76 (% of GDP) and 80 (% of GDP) are respectively, negative trade thresholds for government effectiveness and economic governance. The corresponding negative trade thresholds for the rule of law, corruption-control and institutional governance are respectively, 230 (% of GDP), 63.5 (% of GDP) and 106.5 (% of GDP). The established thresholds make economic sense and are actionable policy measures because they are within the ranges of trade openness and FDI disclosed in the summary statistics.

It is also relevant complement this concluding implications by emphasizing that the negative thresholds are associated with Kuznets shapes whereas positive thresholds are linked with inverted U shapes. Therefore, in the light of the motivation of this research which is that establishing Kuznets and U shapes from investigating the EKC hypothesis is not enough for actionable policies, complementary net effects and policy thresholds established in this study are worthwhile because they avail room for more policy implications.

In the light of the above, this study has fulfilled its goal of providing actionable openness policy thresholds to inform policy makers on how governance interacts with globalization to promote the green economy. The study has shown that these thresholds are

contingent on governance dynamics and hence, given the divergent context of governance in sub-Saharan Africa, countries with poor governance standards may need higher globalization thresholds compared to their counterparts with better governance standards. This inference is premised on the fact that the unconditional incidence of governance on CO2 emissions is overwhelmingly positive while globalization contributes towards dampening the underlying positive incidence of the governance dynamics on CO2 emissions.

The findings also inform policy makers that with the implementation of the African Continental Free Trade Area (AfCFTA) in 2021 which is designed to improve trade openness within Africa, the attendant incidence of trade openness in favorably modulating governance to promote the green economy in Africa would be enhanced. Such enhancement would be more apparent if AfCFTA policies surrounding the promotion of sustainable development by means of preserving the environment are properly implemented by sampled countries who have signed the AfCFTA Agreement.

While the findings of this study are relevant to other developing countries, the corresponding trade thresholds in the attendant developing countries may be much lower compared to the sampled countries in this study because other developing countries have comparatively higher standards of governance on the one hand and on the other, over the past 70 years, while the share of other developing countries in world trade has been increasing, the corresponding share of Africa has decreased by more than 50% over the same period (Fofack, 2014). Accordingly, governance variables have both positive and negative values and the countries in Sub-Saharan Africa have been documented to be associated with more negative values compared to other developing countries (Tchamyou, 2021). Moreover, Africa's contribution to world trade has dropped to 1.5% from more than 3.8% in the 1950s (Asongu & Tchamyou, 2020).

The principal caveat of this research is that country-specific effects are eliminated because the GMM approach is tailored to eliminate such country-specific impacts in order to control for endogeneity. Hence, future research should engaged relevant estimation approaches to assess whether the established tendencies in this study withstand empirical scrutiny from country-specific frameworks.

Appendices

Appendix 1: Definitions of variables

Variables	Signs	Definitions of variables (Measurements)	Sources
CO_2 per capita	CO2mtpc	CO_2 emissions (metric tons per capita)	World Bank (WDI)
Political Stability	PolS	"Political stability/no violence (estimate): measured as the perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional and violent means, including domestic violence and terrorism"	World Bank (WGI)
Voice & Accountability	VA	"Voice and accountability (estimate): measures the extent to which a country's citizens are able to participate in selecting their government and to enjoy freedom of expression, freedom of association and a free media".	World Bank (WGI)
Political Governance	Polgov	First Principal Component of Political Stability and Voice & Accountability. The process by which those in authority are selected and replaced.	PCA
Government Effectiveness	GE	"Government effectiveness (estimate): measures the quality of public services, the quality and degree of independence from political pressures of the civil service, the quality of policy formulation and implementation, and the credibility of governments' commitments to such policies".	World Bank (WGI)
Regulation Quality	RQ	"Regulation quality (estimate): measured as the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development".	World Bank (WGI)
Economic Governance	Ecogov	"First Principal Component of Government Effectiveness and Regulation Quality. The capacity of government to formulate & implement policies, and to deliver services".	PCA
Rule of Law	RL	"Rule of law (estimate): captures perceptions of the extent to which agents have confidence in and abide by the rules of society and in particular the quality of contract enforcement, property rights, the police, the courts, as well as the likelihood of crime and violence".	World Bank (WGI)
Corruption-Control	CC	"Control of corruption (estimate): captures 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".	World Bank (WGI)
Institutional Governance	Instgov	First Principal Component of Rule of Law and Corruption-Control. The respect for citizens and the state of institutions that govern the interactions among them	PCA
General Governance	Ggov	First Principal Component of Political, Economic and Institutional Governances	PCA
Trade Openness	Trade	Exports plus Imports of Goods and Services (% of GDP)	World Bank (WDI)
Financial Openness	FDI	Net Foreign Direct Investment Inflows (% of GDP)	World Bank (WDI)
GDP growth	GDPg	Gross Domestic Product (GDP) growth (annual %)	World Bank (WDI)
Population growth	Popg	Population growth rate (annual %)	World Bank (WDI)
Educational Quality	Educ	Pupil teacher ratio in Primary Education	World Bank (WDI)

WDI: World Bank Development Indicators. WGI: World Governance Indicators. PCA: Principal Component Analysis.

Appendix 2: Summary statistics (2000-2012)

	Mean	SD	Minimum	Maximum	Observations
CO_2 per capita	0.911	1.842	0.016	10.093	532
Political Stability	-0.486	0.923	-2.660	1.192	496
Voice & Accountability	-0.543	0.687	-1.838	0.986	496
Political Governance	0.140	1.230	-2.653	2.583	496
Government Effectiveness	-0.697	0.584	-1.960	0.934	496
Regulation Quality	-0.604	0.542	-2.110	0.983	496
Economic Governance	0.205	1.225	-2.288	3.807	496
Rule of Law	-0.663	0.614	-2.113	1.056	496
Corruption-Control	-0.590	0.565	-1.566	1.249	496
Institutional Governance	0.144	1.282	-2.391	3.766	496
General Governance	0.284	2.040	-4.567	5.561	496
Trade Openness	76.759	35.381	20.964	209.874	519
Financial Openness	5.381	8.834	-6.043	91.007	529
GDP growth	4.801	5.054	-32.832	33.735	530
Population growth	2.335	0.876	-1.081	6.576	495
Educational Quality	43.892	14.775	12.466	100.236	397

S.D: Standard Deviation.

Appendix 3: Correlation matrix (uniform sample size: 347)

	Governance Dynamics												Control variables			Dependent Variable
	Political Governance			Economic Governance			Institutional Governance			Openness						
	PolS	VA	Polgov	GE	RQ	Ecogov	RL	CC	Instgov	G.gov	Trade	FDI	GDPg	Popg	Educ	CO2mtpc
PolS	1.000															
VA	0.719	1.000														
Polgov	0.928	0.925	1.000													
GE	0.678	0.759	0.775	1.000												
RQ	0.627	0.703	0.717	0.883	1.000											
Ecogov	0.674	0.756	0.771	0.974	0.966	1.000										
RL	0.813	0.829	0.886	0.891	0.829	0.889	1.000									
CC	0.719	0.718	0.775	0.857	0.775	0.844	0.867	1.000								
Instgov	0.792	0.800	0.858	0.904	0.830	0.896	0.965	0.967	1.000							
G.gov	0.839	0.872	0.923	0.937	0.886	0.941	0.967	0.913	0.972	1.000						
Trade	0.270	0.106	0.204	0.114	0.065	0.094	0.217	0.179	0.204	0.177	1.000					
FDI	-0.01	-0.03	-0.030	-0.10	-0.14	-0.126	-0.06	-0.02	-0.082	-0.08	0.344	1.000				
GDPg	-0.09	-0.01	-0.060	-0.01	-0.08	-0.045	-0.05	-0.06	-0.063	-0.05	-0.02	0.170	1.000			
Popg	-0.34	-0.26	-0.328	-0.41	-0.28	-0.362	-0.38	-0.45	-0.433	-0.39	-0.43	0.086	0.207	1.000		
Educ	-0.35	-0.40	-0.407	-0.39	-0.30	-0.365	-0.41	-0.42	-0.435	-0.42	-0.38	-0.09	0.116	0.440	1.000	
CO2mtpc	0.314	0.412	0.391	0.553	0.399	0.496	0.438	0.493	0.482	0.484	0.174	-0.06	-0.08	-0.537	-0.44	1.000

PolS: Political Stability. VA: Voice & Accountability. Polgov: Political Governance. GE: Government Effectiveness. RQ: Regulation Quality. Ecogov: Economic Governance. FDI: Foreign Direct Investment. RL: Rule of Law. CC: Corruption-Control. Instgov: Institutional Governance. Ggov: General Governance. GDP: Gross Domestic Product growth. Popg: Population growth. Educ: Education quality. CO2mtpc: CO2 emissions per capita.

References

Ades, A., & Di Tella, R., (1999). "Rents, competition and corruption", *American Economic Review*, 89(4), pp. 982-993.

Afful-Koomson, T., (2012). "Governance Challenges for a Green Economy in Africa", United Nations University, https://unu.edu/publications/articles/governance-challenges-for-a-green-economy-in-africa.html (Accessed: 07/04/2017).

Ajide, K. B, & Raheem, I. D., (2016a). "Institutions-FDI Nexus in ECOWAS Countries", *Journal of African Business*, 17(3), pp. 319-341.

Ajide, K. B, & Raheem, I. D., (2016b). "The Institutional Quality Impact on Remittances in the ECOWAS Sub-Region", *African Development Review*, 28(4), pp. 462–481.

Akbostanci, E., S. Turut-Asi & Tunc, G. I., (2009). "The Relationship between Income and Environment in Turkey: Is there an Environmental Kuznets Curve?", *Energy Policy*, 37(3), pp. 861-867.

Akinlo, A. E., (2008). "Energy consumption and economic growth: evidence from 11 Sub-Sahara African countries". *Energy Economics*, 30(5), pp. 2391-2400.

Akinyemi, O., Alege, P., Osabuohien, E., & Ogundipe, A., (2015). "Energy Security and the Green Growth Agenda in Africa: Exploring Trade-offs and Synergies", Department of Economics and Development Studies, Covenant University, Nigeria.

Akinyemi, O., Efobi, U., Asongu, S., & Osabuohien, E., (2018). "Green Growth Strategy and Trade Performance in sub-Saharan Africa", Department of Economics and Development Studies, Covenant University, Nigeria.

Akpan, G. E. & Akpan, U. F. (2012). "Electricity Consumption, Carbon Emissions and Economic Growth in Nigeria", *International Journal of Energy Economics and Policy*, 2(4), pp. 292-306.

Amavilah, V., Asongu, S. A., & Andrés, A. R., (2017). "Effects of globalization on peace and stability: Implications for governance and the knowledge economy of African countries", *Technological Forecasting and Social Change*, 122 (September), pp. 91-103.

Andrés, R. A, Asongu, S. A., & Amavilah, V. H., (2015). "The Impact of Formal Institutions on Knowledge Economy", *Journal of the Knowledge Economy*, 6(4), pp. 1034-1062.

Ang, J. B. (2007). "CO2 emissions, energy consumption, and output in France", *Energy Policy*, 35(10), pp. 4772-4778.

Anyangwe, E. (2014). "Without energy could Africa's growth run out of steam?" *theguardian*, http://www.theguardian.com/global-development-professionals-network/2014/nov/24/energy-infrastructure-clean-cookstoves-africa (Accessed: 08/09/2015).

Apergis, N. & J. Payne, J. E., (2009). "CO2 emissions, energy usage, and output in Central America", *Energy Policy,* 37(8), pp. 3282-3286.

Arellano, M., & Bover, O., (1995), "Another look at the instrumental variable estimation of error components models", *Journal of Econometrics,* 68(1), pp. 29-52.

Ashraf, Q., & Galor, O., (2013). "The Out of Africa Hypothesis, Human Genetic Diversity, and Comparative Economic Development". *American Economic Review,* 103(1), pp. 1-46.

Asongu, S. A., (2013). "How Would Population Growth Affect Investment in the Future? Asymmetric Panel Causality Evidence for Africa", *African Development Review,* 25(1), pp. 14-29.

Asongu, S. A., (2014). "Globalisation (fighting) corruption and development. How are these phenomena linearly and non-linearly related in wealth effects?", *Journal of Economic Studies,* 41(3), pp. 346-369.

Asongu, S. A., (2017). "Knowledge Economy Gaps, Policy Syndromes and Catch-up Strategies: Fresh South Korean Lessons to Africa", *Journal of the Knowledge Economy*, 8(1), pp. 211–253.

Asongu, S. A., (2018a). "ICT, Openness and CO2 emissions in Africa", *Environmental Science and Pollution Research*, 25(10), pp. 9351-9359.

Asongu, S. A., (2018b). "CO2 emission thresholds for inclusive human development in sub-Saharan Africa", *Environmental Science and Pollution Research*, 25(26), pp. 26005-26019.

Asongu S. A., & De Moor, L., (2017). "Financial globalisation dynamic thresholds for financial development: evidence from Africa", *European Journal of Development Research,* 29(1), pp. 192–212.

Asongu, S. A., Efobi, U. R., & Tchamyou, V. S., (2018a). "Globalisation and governance in Africa: a critical contribution to the empirics", *International Journal of Development Issues,* 17(1), pp. 2-27.

Asongu, S. A., le Roux, S., Nwachukwu, J. C., & Pyke, C., (2019)."The Mobile Phone as an Argument for Good Governance in Sub-Saharan Africa", *Information Technology & People,* 32(4), pp. 897-920.

Asongu, S. A., le Roux, S., & Biekpe, N., (2017). "Environmental degradation, ICT and inclusive development in Sub-Saharan Africa", *Energy Policy,* 111(December), pp. 353-361.

Asongu, S. A., le Roux, S.,, & Biekpe, N., (2018). "Enhancing ICT for environmental sustainability in sub-Saharan Africa", *Technological Forecasting and Social Change*, 127(February), pp. 209-216.

Asongu, S. A., & Nwachukwu, J. C., (2016a). "Revolution empirics: predicting the Arab Spring", *Empirical Economics,* 51(2), pp. 439-482.

Asongu, S. A, & Nwachukwu, J. C., (2016b). "The Mobile Phone in the Diffusion of Knowledge for Institutional Quality in Sub Saharan Africa", *World Development*, 86 (October), pp. 133-147.

Asongu, S. A., & Nwachukwu, J. C., (2016c). "The Role of Governance in Mobile Phones for Inclusive Human Development in Sub-Saharan Africa", *Technovation*, 55-56 (September-October), pp. 1-13.

Asongu, S. A, & Nwachukwu, J. C., (2016d). "Foreign aid and governance in Africa", *International Review of Applied Economics*, 30(1), pp. 69-88.

Asongu, S. A., & Nwachukwu, J. C., (2017a)."Quality of Growth Empirics: Comparative Gaps, Benchmarking and Policy Syndromes", *Journal of Policy Modeling*, 39(5), pp.861-882.

Asongu, S. A, & Nwachukwu, J. C., (2017b). "Is the Threat of Foreign Aid Withdrawal an Effective Deterrent to Political Oppression? Evidence from 53 African Countries", *Journal of Economic Issues*, 51(1), pp. 201-221.

Asongu, S. A., & Nwachukwu, J. C., (2017c)." Foreign Aid and Inclusive Development: Updated Evidence from Africa, 2005–2012", *Social Science Quarterly*, 98(1), pp. 282-298.

Asongu, S. A., & Odhiambo, N. M., (2019a). "Environmental Degradation and Inclusive Human Development in Sub- Saharan Africa", *Sustainable Development*, 27(1), pp. 25-34.

Asongu, S. A., & Odhiambo, N. M., (2019b). "Basic formal education quality, information technology, and inclusive human development in sub-Saharan Africa", *Sustainable Development*, 27(3), pp. 419-428.

Asongu, S. A., & Odhiambo, N. M., (2019c). "Mobile banking usage, quality of growth, inequality and poverty in developing countries", *Information Development*, 35(2), pp.303-318.

Asongu, S. A., & Odhiambo, N. M., (2021a). "The green economy and inequality in Sub-Saharan Africa: Avoidable thresholds and thresholds for complementary policies", *Energy Exploration & Exploitation*, DOI: 10.1177/0144598720984226.

Asongu, S. A., & Odhiambo, N. M., (2021b). "Enhancing governance for environmental sustainability in sub-Saharan Africa", *Energy Exploration & Exploitation*, 39(1), pp. 444-463.

Asongu, S. A., & Tchamyou, V. S., (2020). "Human Capital, Knowledge Creation, Knowledge Diffusion, Institutions and Economic Incentives: South Korea Versus Africa", *Contemporary Social Science*, 15(1), pp. 26-47.

Batuo, M. E., (2015). "The role of telecommunications infrastructure in the regional economic growth of Africa", *Journal of Development Areas*, 49(1), pp. 313-330.

Beck, T., Demirgüç-Kunt, A., & Levine, R., (2003), "Law and finance: why does legal origin matter?", *Journal of Comparative Economics*, 31(4), pp. 653-675.

Bhagwati, J. (1982). "Directly unproductive, profit-seeking (DUP) activities", *Journal of Political Economy*, 90(5), pp. 988-1002.

Bhagwati, J. & Srinivasan, T. N. (1980). "Revenue seeking: a generalisation of the theory of tariffs", *Journal of Political Economy*, 88(6), pp. 1069-1087.

Begum, R. A., Sohag, K., Abdullah S. M. S., & Jaafar, M., (2015). "CO2 emissions, energy consumption, economic and population growth in Malaysia", *Renewal and Sustainable Energy Reviews*, 41(January), pp. 594-601.

Boateng, A., Asongu, S, Akamavi, R., & Tchamyou, V., (2018). "Information asymmetry and market power in the African banking industry", *Journal of Multinational Financial Management*, 44(March), pp. 69-83.

Bölük, G., & Mehmet, M., (2015). "The renewable energy, growth and environmental Kuznets curve in Turkey: An ARDL approach", *Renewal and Sustainable Energy Reviews*, 52(December), pp. 587-595.

Bonaglia, F., Braga de Macedo, J. & Bussolo, M. (2001). "How globalization improves governance", *Working Paper*, No. 181, OECD, Paris.

Bruno, G., De Bonis, R., & Silvestrini, A., (2012). "Do financial systems converge? New evidence from financial assets in OECD countries". *Journal of Comparative Economics*, 40(1), pp. 141-155.

Chemutai, B., (2009). "Achieving Effective National Environmental Governance in Africa", I SS Today, https://issafrica.org/iss-today/achieving-effective-national-environmental-governance-in-africa (Accessed: 07/04/2017).

Efobi, U., Tanankem, B., Orkoh, E., Atata, S. N., Akinyemi, O., & Beecroft, I., (2019). "Environmental Pollution Policy of Small Businesses in Nigeria and Ghana: Extent and Impact", *Environmental Science and Pollution Research*, 26(3), pp 2882–2897.

Esso, L. J. (2010). "Threshold cointegration and causality relationship between energy use and growth in seven African countries", *Energy Economics*, 32(6), pp. 1383-1391.

Diao, X. D., Zeng, S. X., Tam, C. M. & Tam, V. W .Y., (2009). "EKC Analysis for Studying Economic Growth and Environmental Quality: A Case Study in China", *Journal of Cleaner Production*, 17(5), pp. 541-548.

Fofack, H., (2014). "The Idea of Economic Development: Views from Africa", *WIDER Working Paper* 2014/093, Helsinki.

Gatti, R. (1999). "Corruption and trade tariffs, or a case for uniform tariffs", *Working Paper*. No. 2216, *World Bank Policy Research*, Washington, DC.

He, J., & Richard, P., (2010). "Environmental Kuznets Curve for Co2 in Canada", *Ecological Economics*, 69(5), pp. 1083-1093.

Hongwu, L., (2013). "How to solve African governance and development issues: A perspective from China", BRIDGES AFRICA, http://www.ictsd.org/bridges-news/bridges-africa/news/how-to-solve-african-governance-and-development-issues-a (Accessed: 07/04/2017).

Jarrett, M. B., (2017). "Lights out: poor governance and Africa's energy crisis", *The Africa Report*. http://www.theafricareport.com/News-Analysis/lights-out-africas.html (Accessed: 01/12/2018).

Jolliffe, I. T. (2002) Principal Component Analysis (2nd Ed.) New York: Springer.

Jones, K. R., (2003). "Multilateral Environmental Agreements in Africa: Efforts and Problems in Implementation", *International Environmental Agreements*, 3(2), pp. 97-135.

Jumbe, C. B., (2004). "Cointegration and Causality between Electricity Consumption and GDP: Empirical Evidence from Malawi", *Energy Economics*, 26(1), pp. 61-68.

Kaiser, H. F. (1974) "An index of factorial simplicity" *Psychometrika* 39(1), pp. 31–36.
Kangoye, T., (2013). "Does Aid Unpredictability Weaken Governance? Evidence From Developing Countries", *The Developing Economies*, 51(2), pp. 121-144.

Kaufmann, D., Kraay, A & Mastruzzi, M., (2010). "The worldwide governance indicators: Methodology and analytical Issues". *World Bank Policy Research Working Paper* No 5430, Washington.

Kifle, T. (2008). "Africa hit hardest by Global Warming despite its low Greenhouse Gas Emissions", *Institute for World Economics and International Management Working Paper* No. 108, http://www.iwim.uni-bremen.de/publikationen/pdf/b108.pdf (Accessed: 08/09/2015).

Klitgaard, R. (1988). Controlling Corruption, University of California Press, Berkeley, CA and London.

Krueger, A. (1974), "The political economy of the rent seeking society", *American Economic Review,* 64(3), pp. 291-303.

Lalountas, D.A., Manolas, G.A., & Vavouras, I. S., (2011), " Corruption, globalization and development: How are these three phenomena related?", *Journal of Policy Modeling*, 33(4), pp. 636-648.

McGrath, M., (2018). "Cars and coal help drive 'strong' CO2 rise in 2018", *Science & Environment,* https://www.bbc.com/news/science-environment-46447459 (Accessed: 09/12/2018)

Mehrara, M., (2007). "Energy consumption and economic growth: The case of oil exporting countries", *Energy Policy*, 35(5), pp. 2939-2945.

Meniago, C., & Asongu, S. A., (2018). "Revisiting the finance-inequality nexus in a panel of African countries", *Research in International Business and Finance,* 46(December), pp. 399-419.

Menyah, K., & Wolde-Rufael, Y., (2010). "Energy consumption, pollutant emissions and economic growth in South Africa", *Energy Economics*, 32(6), pp. 1374-1382.

Narayan, P.K., Mishra, S., & Narayan, S., (2011). "Do market capitalization and stocks traded converge? New global evidence". *Journal of Banking and Finance,* 35(10), pp.2771-2781.

Odhiambo, N. M., (2009a). "Electricity consumption and economic growth in South Africa: a trivariate causality test". *Energy Economics,* 31(5), pp. 635–640.

Odhiambo, N. M., (2009b). "Energy consumption and economic growth nexus in Tanzania: an ARDL bounds testing approach". *Energy Policy,* 37 (2), pp. 617–622.

Odhiambo, N. M., (2010). "Energy Consumption, Prices and Economic Growth in Three SSA Countries: A Comparative Study" *Energy Policy*, 38(5), pp. 2463-2469.

Odhiambo, N. M., (2014a). "'Energy Dependence in Developing Countries: Does the Level of Income Matter'", *Atlantic Economic Journal*, 42(1), pp. 65–77.

Odhiambo, N. M., (2014b). "Electricity Consumption, Exports And Economic Growth in the Democratic Republic of Congo: An ARDL-Bounds Testing Approach", *Journal of Developing Areas*, 48(4), pp.189-207.

Oluwatobi, S., Efobi, U.R., Olurinola, O.I., & Alege, P. (2015). "Innovation in Africa: Why Institutions Matter", *South African Journal of Economics*, 83(3), pp. 390-410.

Osabuohien, E. S., & Efobi, U. R., (2013). "Africa's money in Africa", *South African Journal of Economics*, 81(2), pp. 292-306.

Olusegun, O. A., (2008). "Consumption and Economic Growth in Nigeria: A bounds testing cointegration approach", *Journal of Economic Theory*, 2(4), pp. 118-123.

Ozturk, I., & Acaravci, A., (2010). "CO2 emissions, energy consumption and economic growth in Turkey", *Renewable and Sustainable Energy Reviews*, 14(9), pp. 3220-3225.

Roodman, D., (2009a). "A Note on the Theme of Too Many Instruments", *Oxford Bulletin of Economics and Statistics,* 71(1), pp. 135-158.

Roodman, D., (2009b). "How to do xtabond2: An introduction to difference and system GMM in Stata", *Stata Journal,* 9(1), pp. 86-136.

Shurig, S. (2015). "Who will fund the renewable solution to the energy crisis?",the guardian, http://www.theguardian.com/global-development-professionalsnetwork/2014/jun/05/renewable-energy-electricty-africa-policy (Accessed: 08/09/2015).

Tchamyou, V. S., (2017). "The Role of Knowledge Economy in African Business". *Journal of the Knowledge Economy*, 8(4), pp. 1189-1228.

Tchamyou, V. S., (2019)."The Role of Information Sharing in Modulating the Effect of Financial Access on Inequality". *Journal of African Business*, 20(3), pp. 317-338.

Tchamyou, V. S., (2020). "Education, Lifelong learning, Inequality and Financial access: Evidence from African countries". *Contemporary Social Science*. 15(1), pp. 7-25.

Tchamyou, V. A., (2021). "Financial access, governance and the persistence of inequality in Africa: Mechanisms and policy instruments", *Journal of Public Affairs*: DOI: 10.1002/pa.2201.

Tchamyou, V. S., & Asongu, S. A., (2017). "Information Sharing and Financial Sector Development in Africa", *Journal of African Business*, 18(7), pp. 24-49.

Tchamyou, V.S., Erreygers, G., & Cassimon, D., (2019). "Inequality, ICT and Financial Access in Africa", *Technological Forecasting and Social Change*, 139(February), pp. 169-184.

Wei, S.J. (2000), "Natural openness and good governance", *Working Paper*, No. 7765, NBER, Cambridge, MA.