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Abstract

This study investigates linkages between environmental degradation, globalisation and governance in 44 countries in Sub-Saharan Africa using data for the period 2000-2012. The Generalised Method of Moments is employed as empirical strategy. Environmental degradation is proxied by carbon dioxide emissions whereas globalisation is appreciated in terms of trade openness and net foreign direct investment inflows. Bundled and unbundled governance indicators are used, namely: political governance (consisting of political stability/no violence and "voice & accountability"), economic governance (encompassing government effectiveness and regulation quality), institutional governance (entailing corruption-control and the rule of law) and general governance (a composite measurement of political governance, economic governance and institutional governance). The following main finding is established. Trade openness modulates carbon dioxide emissions to have positive net effects on political stability, economic governance, the rule of law and general governance.

1. Introduction

How does globalisation and environmental degradation affect domestic governance in sub-Saharan Africa? The question that motivates the present research builds on at least four features in the scholarly literature, notably: (i) the ineluctable phenomenon of globalisation; (ii) the relevance of environmental sustainability in the post-2015 era of Sustainable Development Goals; (iii) the importance of enhanced governance standards in the sub-region and (iv) gaps in the attendant literature. These features are expanded in the subsequent paragraphs.

First, there are growing calls in policy and scholarly circles for globalisation to be given a human face (UN, 2013; Asongu, 2013; Stiglitz, 2007; Kenneth & Himes, 2008). According to the narrative, globalisation is an ineluctable process that can only be stopped at the price of putting the prosperity of people and nations in danger. Accordingly, the phenomenon is threatening domestic governments and the emancipation of the citizens because it promotes self-interest by prioritising the domination of markets over domestic governments' interests. In essence, while the phenomenon of globalisation has been empirically established to influence domestic governance standards (Klitgaard, 1988; Farazmand, 1999; Lalountas, Manolas & Vavouras, 2011; Asongu, Efobi & Tchamyou, 2018a), it has also been recently documented to be the principal driver of carbon dioxide emissions (You & Lv, 2018).

Second, carbon dioxide emissions which are at an all time high (McGrath, 2018) represent a considerable challenge to environmental sustainability in the light of Sustainable Development Goals which centre on the promotion of the green economy (Asongu, le Roux & Biekpe, 2017, 2018b; Efobi et al., 2019). McGrath (2018) further maintains that net outputs from green growth are not enough to dampen the growing pollution of the environment. According to the author, these carbon dioxide emissions are principally determined by two main tendencies: (i) globalization-oriented policies. (ii) Measures aimed at promoting the green economy which, are more traceable to efforts from domestic governments rather than from multinational companies. The underlying concerns are most relevant to sub-Saharan Africa because three key factors motivating this research are very apparent in the sub-region. (i) Sub-Saharan Africa is contributing less to World Trade compared to the 1960s (Fofack, 2014). (ii) The consequences of rising carbon dioxide emissions are projected to be most detrimental in sub-Saharan Africa (Kifle, 2008; Apkan & Apkan, 2012; Shurig, 2015; Asongu

& Odhiambo, 2019a). (iii) The sub-regionis characterised by the least standards of governance in the world (Asongu, 2014a; Ajide & Raheem, 2016a, 2016b).

Third, it is relevant to improve governance standards in sub-Saharan Africa because good governance has been established to enhance economic development outcomes on a multitude of fronts, notably in: societal change (Efobi, 2015) and more effective management of economic resources (Fosu, 2013, 2015a, 2015b; Anyanwu & Erhijakpor, 2014).

Fourth, the attendant literature has substantially focused on the environmental degradation consequences of low political will and poor governance. Some studies supporting this view include: Jones (2003), Odhiambo (2009a, 2009b, 2010), Afful-Koomson (2012), Apkan and Akpan (2012), Hongwu (2013), Chemutai (2009), Anyangwe (2014), Odhiambo (2014a, 2014b), Akinyemi, Alege, Osabuohien and Ogundipe (2015), Jarrett (2017), Akinyemi, Efobi, Asongu and Osabuohien (2018), Asongu (2018a) and Efobi et al. (2019).This research departs from the mainstream literature by investigating the relevance of carbon dioxide emissions in domestic governance, continent on globalization. Hence the question this research aims to answer is the following: how do globalization-driven carbon dioxide emissions affect governance standards in sub-Saharan Africa?

With respect to African-centric literature, the studies closest to this paper are Asongu (2018b) and Asongu *et al.* (2018a) which have respectively, established the connection between globalization and carbon dioxide emissions and the relationship between globalization and governance. In essence, Asongu (2018b) has investigated linkages between information and communication technology, globalization and carbon dioxide emissions while Asongu *et al.* (2018a) have contributed to the empirics by establishing that various components of globalization affect governance dynamics. The current research builds on these two studies in the light of the identified shortcomings in the environmental degradation literature, to assess how globalization-moderated carbon dioxide emissions influence governance standards in sub-Saharan Africa.

In order to improve room for policy implications, six governance dynamics from the World Governance Indicators of the World Bank (i.e. political stability/no violence, "voice & accountability", government effectiveness, regulation quality, corruption-control and the rule of law) are bundled to produce additional composite governance measurements (i.e. political governance, economic governance, institutional governance and general governance). 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).

The purpose of bundling and unbundling governance indicators is motivated by evolutions in the measurement, conception and use of the term "governance" in scientific scholarly reporting. For example, in the light of the definitions provided in the preceding paragraph from Andrés *et al.* (2015), it is inappropriate to employ the term "economic governance" in scholarly reporting unless it is measured with constituent indicators of government effectiveness and regulation quality. Therefore, it is for the purpose of limiting conceptual conflation that the engaged governance dynamics are bundled through principal component analysis. Such bundling innovations enable the definition and conception of governance indicators to be consistent with measurements in scholarly reporting. A good illustration in the literature, of a study which has conflated the conception and measurement of governance is Kangoye (2013). While Kangoye (2013) uses corruption in the empirical exercise, the narratives are discussed in terms of general governance. According to the context of the present research, corruption-control is only a dimension of institutional governance and institutional governance is also only a dimension of general governance. In the light of the attendant critique, this study argues that the term "general governance" can only be used in narratives if it is a composite measurement consisting of political stability, "voice & accountability", government effectiveness, regulation quality, corruption-control and the rule of law (Asongu & Odhiambo, 2019b).

In the light of the three main categories of governance dynamics covered in this study, the intuition for globalisation in modulating "environmental degradation"-driven governance can be discussed in three main strands. First, from the perspective of political governance, we argue that environmental degradation can influence political governance because it can affect civil unrests and demand for "voice & accountability" in the manner in which, elected leaders take decisions on issues surrounding environmental standards. The associated connection between environmental degradation and political governance is even more apparent when trade and foreign direct investment processes are involved. Accordingly, multinational and domestic companies (through trade and investments) participate in environmental quality and

the citizens are very likely to demand better political governance when environmental standards are poor.

Second, environmental degradation from globalization activities can also influence governance in the perspective that, leaders respond by improving economic governance through *inter alia*: the formulation and implementation of policies that effectively deliver public commodities, such as health, education and transport facilities. Third, the respect of the State and citizens of institutions that govern interactions between them (i.e. institutional governance) can also be improved from interactions between globalization and environmental degradation. Accordingly, such interactions can be associated with corruption and disrespect of the rule of law. Hence, in response, institutional governance is likely to be improved.

In the light of the above, this research anticipates an overall positive net effect on governance standards from the role of globalization in modulating the relationship between environmental degradation and governance. Given the intuition motivating this study, the research is aligned with a framework of theory-building. Therefore, consistent with contemporary empirical research, this study is in accordance with arguments that applied econometrics is not exclusively motivated by the need to accept or reject existing theoretical underpinnings (Narayan, Mishra & Narayan, 2011; Asongu & Nwachukwu, 2016a). Hence, the research argues that applied econometrics based on sound intuition is also a useful scientific activity that can lead to theory-building.

The anticipated theoretical insights are broadly consistent with Farazmand (2004) and Farazmand and Pinkowski (2006) on nexuses between globalization, institutional ramifications and macroeconomic outcomes such as global insecurity, national sovereignty, income inequality as well as public and environmental health. Accordingly, beyond the concern of governance which is used as the outcome variable in this study, Farazmand (2004) and Farazmand and Pinkowski (2006) also document that globalization is linked to the independent variable of interest used in this study (i.e. carbon dioxide emissions) by articulating that globalization is directly linked to concerns of sustainable development such as climate change and the sustainable use of energy.

The rest of the research proceeds as follows. Section 2 covers the data and the methodology. The empirical results are disclosed and discussed in Section 3 while Section 4 concludes with future research directions.

2. Data and methodology

2.1 Data

The study is focused on 44 countries in sub-Saharan Africa using data from 2000 to 2012[1]. The geographical and temporal scopes of the research are contingent on data availability constraints at the time of the study. The data come from five main sources. (i) The six governance indicators (political stability/no violence, "voice & accountability", government effectiveness, regulation quality, corruption-control and the rule of law) are obtained from World Governance Indicators of the World Bank. (ii) The additional four composite governance indicators (political, economic, institutional and general governance) are obtained from principal component analysis. (iii) A control variable (i.e. credit access) comes from the Financial Development and Structure Database of the World Bank. (iv) The carbon dioxide emission variable, globalization indicators (i.e. trade openness and foreign direct investment) and two control variables (i.e. education and foreign aid) are from World Development Indicators of the World Bank. (v) A control variable (i.e. inequality-adjusted human development) is sourced from the United Nations Development Program.

"Carbon dioxide emissions per capita" is adopted as the environmental degradation variable while trade openness and foreign direct investment are appreciated in the terms of respectively, "imports plus exports" and net foreign direct investment inflows. The choice of these variables is motivated by contemporary environmental pollution literature (Asongu, 2018b).

The governance indicators which have been defined in the introduction are from Kaufmann, Kraay and Mastruzzi (2010). They are increasingly being used in the African governance literature: Oluwatobi, Efobi, Olurinola and Alege (2015), Ajide and Raheem (2016a, 2016b) and Asongu and Nwachukwu (2017).

Four main control variables are adopted in order to account for variable omission bias, namely: education quality, credit access, foreign aid and inclusive development. While inclusive development is expected to promote governance, education and foreign aid are expected to have the opposite effects while the anticipated impact from credit access cannot

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[1]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".

be established with certainty because it is contingent on whether such credit access is limited to the rich fractions of the population or not.

Whereas Okada and Samreth (2012) have concluded that foreign aid reduces corruption in developing nations, Asongu and Nwachukwu (2016b) have used the six governance variables employed in this research to establish that foreign aid reduces governance standards in Africa. The education quality indicator is measured as the pupils-teacher ratio. Hence, a negative effect is anticipated on governance quality because the variable reflects a policy syndrome. This is essentially because a higher ratio reflects poor education quality since more pupils are accommodated by fewer teachers. The choice of primary education, relative to other measures (or higher levels of education) has two main motivations. On the one hand, there are data availability constraints in the other levels of education. On the other hand, the primary level of education has been documented to be more associated with development externalities when countries are at initial levels of industrialisation. Some studies supporting this thesis are: Asiedu (2014) and Petrakis and Stamatakis (2002).

In recent African development literature, Asongu and le Roux (2019) have shown that inclusive development promotes good governance. 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

In accordance with the motivation of the study, in order to improve room for policy implications, the governance variables are bundled with principal component analysis. The relevance of bundling governance indicators in order to improve options for policy makers is consistent with recent literature, notably: Tchamyou (2017) and Asongu, le Roux, Nwachukwu and Pyke (2019). Four composite indicators are derived from the principal component analysis: (i) political stability/no violence and "voice & accountability" are reduced to political governance; (ii) government effectiveness and regulation quality are reduced to economic governance; (iii) corruption-control and the rule of law are reduced to institutional governance and (iv) political stability/no violence, "voice & accountability", government effectiveness, regulation quality, corruption-control and the rule of law are reduced to general governance.

The criterion used to select common factors is from Kaiser (1974) and Jolliffe (2002). They recommend that common factors should be retained if they have an eignenvalue greater than the mean and reflect about 70% of common information in constituent variables. The results of the principal component analysis are disclosed in Table 1. It is apparent from the table that the discussed criterion is fulfilled because: political governance, institutional governance, economic governance and general governance respectively, reflect eigenvalues (variations) of 1.671, 1.861, 1.878 and 4.892 (83.5 %, 93.0 %, 93.9 % and 81.50%).

Table 1: Principal Component Analysis for Governance

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

This research borrows from recent literature on the motivation for employing the Generalised Method of Moments because such motives are consistent with the data behavior and modeling approach for this research. In accordance with the attendant literature (Tchamyou, 2019a, 2019b; Asongu & Nwachukwu, 2016c; Fosu & Abass, 2019), the choice of this empirical strategy is informed by four main factors. First, the governance dynamics (i.e. the outcome variables) are persistent given that the correlation between their level values and first lagged values is higher than 0.800, which is the rule of thumb for establishing such persistence (Tchamyou et al., 2019; Boateng, Asongu, Akamavi & Tchamyou, 2018). Second, N (i.e. the number of countries) is higher than T (i.e. the number of periods in each country). Third, given the panel data structure of the study, cross-country variations are considered in the estimation exercise. Fourth, the issue of endogeneity is addressed from two main perspectives. On the one hand, an instrumentation process is employed to account for

simultaneity or reverse causality. On the other hand, the unobserved heterogeneity is taken on board because the estimation process controls from time-invariant variables and by extension, cross sectional dependence.

The Roodman (2009a, 2009b) extension of Arellano and Bover (1995) is employed in this study because in the light of contemporary literature, it limits the proliferation of instruments and has more efficient properties.

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

$$G_{i,t} = \sigma_0 + \sigma_1 G_{i,t-\tau} + \sigma_2 C_{i,t} + \sigma_3 O_{i,t} + \sigma_4 CO_{i,t} + \sum_{h=1}^{4} \delta_h W_{h,i,t-\tau} + \eta_i + \xi_t + \varepsilon_{i,t} \qquad (1)$$

$$G_{i,t} - G_{i,t-\tau} = \sigma_1(G_{i,t-\tau} - G_{i,t-2\tau}) + \sigma_2(C_{i,t} - C_{i,t-\tau}) + \sigma_3(O_{i,t} - O_{i,t-\tau}) + \sigma_4(CO_{i,t} - CO_{i,t-\tau})$$
$$+ \sum_{h=1}^{4} \delta_h(W_{h,i,t-\tau} - W_{h,i,t-2\tau}) + (\xi_t - \xi_{t-\tau}) + (\varepsilon_{i,t} - \varepsilon_{i,t-\tau}) \qquad (2)$$

where, $G_{i,t}$ is a governance (political stability, voice & accountability, government effectiveness, regulation quality, rule of law and corruption-control, political governance, economic governance, institutional governance and general governance) variable of country i in period t, σ_0 is a constant, C represents carbon dioxide emissions, O entails openness (trade openness and financial openness), CO denotes an interaction between a carbon dioxide emission variable and openness ("carbon dioxide emissions" × "trade openness" and "carbon dioxide emissions" × "financial openness"), W is the vector of control variables (*education, credit, foreign aid* and *inclusive development*), 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

The identification and exclusion narrative in this research is broadly consistent with recent literature which has employed the Generalised Method of Moments approach, notably: Asongu and Nwachukwu (2016d), Tchamyou and Asongu (2017), Meniago and Asongu (2018), Tchamyou *et al.* (2019) and Boateng *et al.* (2018).According to the attendant strategy, years or time-invariant variables are considered as strictly exogenous variables while all the explanatory indicators are acknowledged as predetermined. Roodman (2009b) is sympathetic

with this identification strategy because the author has argued that it is unfeasible for time-invariant variables to be endogenous upon a first difference[2].

The exclusive restrictions and identification frameworks are aligned in the perspectives that, the strictly exogenous variables influence the outcome variable exclusively through the predetermined variables. The underlying assumption of exclusion restriction is assessed with the Difference in Hansen Test. The null hypothesis of this test is the position that the instruments are valid and the exclusion restriction assumption is validated if the null hypothesis is not rejected. While this information criterion on exclusion restriction is that which is used in the Generalised Method of Moments with forward orthogonal deviations, the strategy is not different from a standard instrumental variable strategy in which, a rejection of the null hypothesis of the Sargan test implies that the instruments are not valid (Beck, Demirgüç-Kunt & Levine, 2003; Asongu & Nwachukwu, 2016b).

3. Presentation of results
3.1 Empirical results

This section discloses the empirical results. Table 2 presents nexuses between globalization, environmental degradation and political governance while Table 3 shows findings on linkages between globalization, environmental degradation and economic governance. The findings in Table 4 are connections between globalization, environmental degradation and institutional governance, whereas the focus of Table 5 is on globalization, environmental degradation and general governance. With the exception of Table 5 which focuses on general governance, Table 2-4 entail three sets of specifications pertaining to each governance dynamic. In each table, the first-two specifications are constituents of the composite governance indicator derived from principal component analysis. The last specification is therefore the composite indicator from the principal component analysis. Each specification set entails two main regressions pertaining to trade-linked and "foreign direct investment"-oriented estimations.

In order to assess the validity of estimated models, four information criteria are used[3].Based on these criteria, some models do not pass post-estimation diagnostic tests,

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

[3] "*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*

notably: (i) the fourth and sixth columns of Table 2; (ii) the first-three specifications of Table 3; (iii) the last-four specifications of Table 4 and (iv) the fourth column of Table 5.

Table 2: Globalisation, Carbon dioxide emissions and Political Governance

	Dependent variable: Political Governance					
	Political Stability (PS)		Voice & Accountability (VA)		Political Governance (Polgov)	
	Trade G.	Financial G.	Trade G.	Financial G.	Trade G.	Financial G.
Political Stability (-1)	**0.836***** **(0.000)**	**0.906***** **(0.000)**	---	---	---	---
Voice & Accountability (-1)	---	---	**0.995***** **(0.000)**	**0.989***** **(0.000)**	---	**---**
Political Governance (-1)	---	---	---	---	**0.939***** **(0.000)**	**0.946***** **(0.000)**
Trade Globalization (Trade)	-0.001 (0.213)	---	**-0.001***** **(0.000)**	---	-0.001 (0.000)	---
Financial Globalization (Fin)	---	-0.0004 (0.480)	---	**-0.0008***** **(0.000)**	---	**-0.0007*** **(0.097)**
CO_2 emissions (CO2)	**0.051*** **(0.090)**	-0.005 (0.781)	**-0.075***** **(0.000)**	-0.009 (0.140)	-0.016 (0.612)	0.023 (0.376)
CO_2 ×Trade	**-0.0005**** **(0.032)**	---	**0.0004***** **(0.000)**	---	-0.00004 (0.866)	---
CO_2× Fin	---	-0.0003 (0.604)	---	**-0.001**** **(0.026)**	---	**-0.002**** **(0.044)**
Education	**-0.011***** **(0.000)**	**-0.006***** **(0.004)**	-0.001 (0.173)	0.0002 (0.870)	**-0.007***** **(0.000)**	**-0.004*** **(0.086)**
Private Domestic Credit	**-0.002**** **(0.030)**	**-0.001*** **(0.077)**	0.0009 (0.371)	**0.001**** **(0.024)**	-0.0005 (0.594)	-0.0005 (0.723)
Foreign Aid	**-0.001*** **(0.089)**	-0.0007 (0.211)	**0.0005*** **(0.057)**	0.0002 (0.402)	0.00007 (0.851)	-0.0001 (0.736)
Inclusive Development	0.407 (0.344)	0.345 (0.370)	**0.537**** **(0.011)**	0.178 (0.273)	**0.767***** **(0.005)**	0.059 (0.829)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Net effects	0.0126	na	nsa	na	na	na
AR(1)	(0.012)	(0.015)	**(0.102)**	**(0.113)**	**(0.027)**	**(0.026)**
AR(2)	**(0.196)**	**(0.247)**	**(0.154)**	**(0.272)**	**(0.448)**	**(0.493)**
Sargan OIR	**(0.748)**	**(0.713)**	(0.003)	(0.009)	**(0.296)**	**(0.538)**
Hansen OIR	**(0.133)**	**(0.435)**	(0.069)	**(0.115)**	(0.070)	**(0.248)**
DHT for instruments (a)Instruments in levels						
H excluding group	**(0.394)**	**(0.193)**	(0.021)	(0.004)	**(0.193)**	(0.008)
Dif(null, H=exogenous)	**(0.117)**	**(0.525)**	**(0.235)**	**(0.608)**	(0.084)	**(0.758)**
(b) IV (years, eq(diff))						
H excluding group	**(0.259)**	**(0.276)**	(0.008)	(0.047)	(0.056)	**(0.243)**
Dif(null, H=exogenous)	**(0.140)**	**(0.614)**	**(0.851)**	**(0.533)**	**(0.284)**	**(0.340)**
Fisher	**22400.92*****	**339.78*****	**4302.11*****	**4587.48*****	**10925.49*****	**23052.72*****
Instruments	39	39	39	39	39	39
Countries	41	41	41	41	41	41
Observations	211	213	211	213	211	213

*, **, ***: 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 included in the regressions.The mean value of trade openness is 76.759 while the mean value of financial openness is 5.381.

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).

One common feature in the invalid models is that the Hansen test is rejected. It is worthwhile to articulate that the Sargan test is not robust but not weakened by instrument proliferation whereas the Hansen test is robust and weakened by instrument proliferation. A means of dealing with the conflicting information criteria is to adopt the Hansen test and then ensure that instrument proliferation is limited. Such instrument proliferation is restricted by ensuring that the number of cross sections is higher than the number of instruments in each specification.

In line with the research question motivating this study, in order to assess how globalisation modulates "environmental degradation"-driven governance, net effects are computed from estimated models that are valid. These net effects consist of the both the unconditional effects of environmental degradation and the corresponding conditional impact which entails the interaction between environmental degradation and a globalization dynamic. For instance in the second column of Table 2, the net impact of trade in modulating the importance of carbon dioxide emissions in political stability 0.0126 ([-0.0005× 76.759] + [0.051]). In this computation, the mean value of trade openness is 76.759, the unconditional effect of carbon dioxide emissions is 0.051 while the conditional impact from the interactions between carbon dioxide emissions and trade openness is -0.0005. This computation framework is consistent with recent literature on interactive regressions (Agoba, Abor, Osei, & Sa-Aadu, 2019; Tchamyou, 2019b).

Table 3: Globalisation, Carbon dioxide emissions and Economic Governance

	Dependent variable: Economic Governance					
	Regulation Quality (RQ)		Government Effectiveness (GE)		Economic Governance (Ecogov)	
	Trade G.	Financial G.	Trade G.	Financial G.	Trade G.	Financial G.
Regulation Quality (-1)	0.859*** (0.000)	0.863*** (0.000)	---	---	---	---
Government Effectiveness (-1)	---	---	0.859*** (0.000)	0.863*** (0.000)	---	---
Economic Governance (-1)	---	---	---	---	0.881*** (0.000)	0.906*** (0.000)
Trade Globalization (Trade)	-0.0004* (0.067)	---	-0.001*** (0.000)	---	-0.002*** (0.000)	---
Financial Globalization (Fin)	---	-0.001*** (0.001)	---	-0.001*** (0.003)	---	-0.002*** (0.001)
CO2 emissions (CO2)	0.164*** (0.000)	-0.008 (0.198)	0.103*** (0.002)	-0.0002 (0.977)	0.290*** (0.000)	-0.003 (0.784)
CO2 ×Trade	-0.001*** (0.000)	---	-0.0008** (0.010)	---	-0.002*** (0.000)	---
CO2× Fin	---	0.002*** (0.000)	---	-0.0002 (0.736)	---	0.002** (0.011)
Education	-0.002*** (0.006)	-0.0008 (0.237)	-0.001 (0.113)	-0.002** (0.028)	-0.004** (0.024)	-0.001 (0.298)
Private Domestic Credit	-0.002** (0.015)	0.002*** (0.001)	-0.002*** (0.009)	0.0006 (0.193)	-0.007*** (0.000)	0.001 (0.118)
Foreign Aid	-0.001*** (0.000)	-0.001*** (0.000)	0.0004 (0.142)	-0.0006*** (0.008)	-0.00006 (0.869)	-0.001*** (0.000)
Inclusive Development	0.490*** (0.000)	-0.021 (0.910)	0.846*** (0.000)	0.413** (0.035)	1.665*** (0.000)	0.421 (0.250)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Net effects	nsa	nsa	nsa	na	0.1364	na
AR(1)	(0.017)	(0.018)	(0.009)	(0.009)	(0.003)	(0.003)
AR(2)	(0.170)	(0.131)	(0.919)	(0.415)	(0.660)	(0.865)
Sargan OIR	(0.033)	(0.001)	(0.089)	(0.004)	(0.101)	(0.001)
Hansen OIR	(0.028)	(0.028)	(0.057)	(0.117)	(0.245)	(0.208)
DHT for instruments						
(a)Instruments in levels						
H excluding group	(0.016)	(0.023)	(0.030)	(0.012)	(0.052)	(0.091)
Dif(null, H=exogenous)	(0.123)	(0.102)	(0.170)	(0.429)	(0.474)	(0.342)
(b) IV (years, eq(diff))						
H excluding group	(0.034)	(0.005)	(0.053)	(0.019)	(0.093)	(0.053)
Dif(null, H=exogenous)	(0.168)	(0.649)	(0.242)	(0.834)	(0.684)	(0.793)
Fisher	26319.03***	18126.65***	3887.09***	4245.93***	14161.67***	7535.81***
Instruments	39	39	39	39	39	39
Countries	41	41	41	41	41	41
Observations	211	213	211	213	211	213

*, **, ***: 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.

The following findings are established from Tables 2-5. In Table 2, trade openness modulates carbon dioxide emissions to induce a positive net effect on political stability. In Table 3, trade openness moderates carbon dioxide emissions to have a net positive impact on economic governance. In Table 4, trade openness modulates carbon dioxide emissions to exert a positive net impact on the rule of law. In Table 5, trade openness moderates carbon dioxide emissions for a positive net impact on general governance. The significant control variables have the expected signs.

Table 4: Globalisation, Carbon dioxide emissions and Institutional Governance

	Dependent variable: Institutional Governance					
	Rule of Law (RL)		Corruption Control (CC)		Institutional Governance (Instgov)	
	Trade G.	Financial G.	Trade G.	Financial G.	Trade G.	Financial G.
Rule of Law (-1)	**1.012*** (0.000)**	**0.968*** (0.000)**	---	---	---	---
Corruption Control (-1)	---	---	**0.826*** (0.000)**	**0.839*** (0.000)**	---	---
Institutional Governance (-1)	---	---	---	---	**0.931*** (0.000)**	**0.924*** (0.000)**
Trade Globalization (Trade)	**0.0008*** (0.001)**	---	**-0.001* (0.094)**	---	-0.001 (0.217)	---
Financial Globalization (Fin)	---	**0.0009*** (0.000)**	---	**-0.002*** (0.001)**	---	-0.0005 (0.492)
CO_2 emissions (CO2)	**0.032** (0.037)**	**-0.010** (0.047)**	-0.029 (0.274)	**-0.033*** (0.002)**	-0.007 (0.792)	**-0.043** (0.013)**
$CO_2 \times$ Trade	**-0.0002*** (0.007)**	---	0.00009 (0.628)	---	-0.0002 (0.257)	---
$CO_2 \times$ Fin	---	-0.00002 (0.497)	---	-0.00009 (0.937)	---	-0.001 (0.526)
Education	**-0.001** (0.014)**	-0.001 (0.192)	0.001 (0.436)	**-0.004*** (0.002)**	-0.001 (0.516)	**-0.006*** (0.001)**
Private Domestic Credit	**-0.001*** (0.009)**	0.0001 (0.623)	0.0005 (0.569)	**0.0009* (0.086)**	-0.001 (0.237)	0.0009 (0.363)
Foreign Aid	**-0.001*** (0.000)**	**-0.001*** (0.000)**	**0.001*** (0.004)**	**-0.0006* (0.052)**	0.0005 (0.504)	**-0.002*** (0.001)**
Inclusive Development	**-0.193** (0.045)**	0.002 (0.974)	**1.183*** (0.000)**	**0.825*** (0.001)**	**1.414*** (0.000)**	**0.835*** (0.006)**
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Net effects	0.0166	na	nsa	nsa	nsa	nsa
AR(1)	(0.044)	(0.042)	(0.002)	(0.001)	(0.002)	(0.001)
AR(2)	**(0.887)**	**(0.924)**	**(0.235)**	**(0.244)**	**(0.936)**	**(0.883)**
Sargan OIR	**(0.120)**	(0.083)	(0.054)	(0.000)	(0.070)	(0.000)
Hansen OIR	**(0.301)**	**(0.140)**	(0.067)	(0.042)	(0.087)	(0.061)
DHT for instruments						
(a)Instruments in levels						
H excluding group	**(0.209)**	(0.071)	(0.010)	(0.010)	(0.034)	(0.023)
Dif(null, H=exogenous)	**(0.358)**	**(0.263)**	**(0.300)**	**(0.213)**	**(0.233)**	**(0.201)**
(b) IV (years, eq(diff))						
H excluding group	**(0.255)**	**(0.180)**	(0.035)	(0.032)	(0.035)	(0.031)
Dif(null, H=exogenous)	**(0.464)**	**(0.222)**	**(0.390)**	**(0.266)**	**(0.504)**	**(0.391)**
Fisher	34449.88***	19661.11***	58956.15***	5130.67***	12904.88***	20906.48***
Instruments	39	39	39	39	39	39
Countries	41	41	41	41	41	41
Observations	211	213	211	213	211	213

*, **, ***: 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: Globalisation, Carbon dioxide emissions and General Governance

	Dependent variable: General Governance			
	Trade G.		Financial G.	
General Governance (-1)	**0.935*****	**0.978*****	**0.954*****	**0.950*****
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**
Trade Globalization (Trade)	-0.0009	-0.0005	---	---
	(0.613)	(0.517)		
Financial Globalization (Fin)	---	---	-0.0009	**-0.002****
			(0.787)	**(0.020)**
CO2 emissions (CO2)	-0.015	**0.147*****	-0.001	**-0.044****
	(0.690)	**(0.001)**	(0.951)	**(0.020)**
CO2 ×Trade	**0.0008***	**-0.001*****	---	---
	(0.095)	**(0.000)**		
CO2× Fin	---	---	**0.002*****	0.002
			(0.033)	(0.194)
Education	0.001	-0.0002	-0.001	**-0.004***
	(0.786)	(0.880)	(0.758)	**(0.084)**
Private Domestic Credit	0.003	**-0.005****	0.001	0.0009
	(0.169)	**(0.015)**	(0.505)	(0.557)
Foreign Aid	---	0.0004	---	**-0.001****
		(0.612)		**(0.010)**
Inclusive Development	---	**1.815*****	---	**1.099*****
		(0.000)		**(0.000)**
Time effects	Yes	Yes	Yes	Yes
Net effects	na	0.0702	nsa	na
AR(1)	(0.005)	(0.010)	(0.004)	(0.009)
AR(2)	**(0.590)**	**(0.935)**	**(0.549)**	**(0.842)**
Sargan OIR	**(0.114)**	(0.083)	(0.032)	(0.007)
Hansen OIR	**(0.157)**	**(0.167)**	(0.015)	**(0.154)**
DHT for instruments				
(a)Instruments in levels				
H excluding group	---	(0.072)	---	(0.013)
Dif(null, H=exogenous)	**(0.397)**	**(0.305)**	**(0.134)**	**(0.514)**
(b) IV (years, eq(diff))				
H excluding group	(0.077)	(0.034)	(0.022)	**(0.136)**
Dif(null, H=exogenous)	**(0.364)**	**(0.821)**	(0.084)	**(0.325)**
Fisher	**734.64*****	**11138.32*****	**727.92*****	**63709.86*****
Instruments	31	39	43	39
Countries	43	41	31	41
Observations	251	211	253	213

*, **, ***: 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.

4. Concluding implications and future research directions

This study investigates linkages between environmental degradation, globalisation and governance in 44 countries in Sub-Saharan Africa using data for the period 2000-2012. The Generalised Method of Moments is employed as empirical strategy. Environmental

degradation is proxied by carbon dioxide emissions whereas the globalisation is appreciated in terms of trade openness and net foreign direct investment inflows. Bundled and unbundled governance indicators are used, namely: political governance (consisting of political stability/no violence and "voice & accountability"), economic governance (encompassing government effectiveness and regulation quality), institutional governance (entailing corruption-control and the rule of law) and general governance (a composite measurement of political governance, economic governance and institutional governance). The following main finding is established. Trade openness modulates carbon dioxide emissions to have positive net effects on political stability, economic governance, the rule of law and general governance.

The interest of unbundling governance dynamics is relevant in these findings because trade openness effectively modulates carbon dioxide emissions to induce positive net effects on some composite governance indicators while it does not on their constituent elements and vice versa. For instance, while it is appropriate to associate the underlying interactions with economic governance, the corresponding association is not appropriate with the constituents of economic governance (i.e. government effectiveness and regulation quality). Moreover, the relevance of the interactions on political stability (i.e. a component of political governance) and the rule of law (i.e. a component of institutional governance) cannot be respectively, extended to political governance and institutional governance. These clarifications are consistent with the motivation of this research of aligning the empirical exercise with progress in the conception, definition and measurement of governance dynamics, in order to avoid conceptual conflation and misplaced policy implications.

Another factor in the findings worth discussing is the fact that some of the models are not valid, especially in "foreign direct investment"-oriented regressions. There are two possible explanations to this tendency: one is ethical and the other is scholarly. On the ethical front, had this research exclusively focused on the trade dimension of globalization, most of the estimated models would have been significant with worthwhile net effects. However, the study has maintained or reported the "foreign direct investment"-oriented regressions in order to avoid the "file drawer" problem in scientific scholarly reporting, notably: the exclusive reporting of strong, significant and expected results and consignment of weak, insignificant and unexpected results to the file drawer (Rosenberg, 2015; Franco, Malhotra & Simonovits, 2014; Boateng *et al*., 2018). Moreover, by reporting the "foreign direct investment"-oriented results, this study is consistent with the view that insignificant and weak results have as much

economic significance and policy relevance as significant and strong findings. Hence, there is a scholarly explanation to the "foreign direct investment"-oriented findings.

On the scholarly front, differences in the role of trade openness vis-à-vis financial openness can be traceable to the debate over the importance on globalization in economic development outcomes in developing countries. According to the attendant literature, while there is a consensus on the beneficial effects of trade openness in economic development, the benefits of financial openness are still subject to intense debates in scholarly circles, especially because of recurrent financial crises that are increasing in magnitude and scale (Prasad & Rajan, 2008; Kose, Prasad& Taylor, 2011; Asongu, 2014b, 2017; Price & Elu, 2014; Motelle & Biekpe, 2015).

The main caveat in the study is that the Generalised Methods of Moment approach is not tailored to account for country-specific effects because these effects are theoretically inconsistent with the application of the empirical approach. Accordingly, country-specific effects are eliminated in order to avoid endogeneity concerns related to the correlation between the lagged dependent variable and country-specific effects. It is therefore worthwhile for future studies to assess whether the established findings withstand empirical scrutiny when relevant empirical approaches are used to engage country-specific studies. Moreover, it would also be worthwhile for future studies to focus on sound governance (as opposed to good governance) by building on insights from Farazmand (2004).

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)
Educational Quality	Educ	Pupil teacher ratio in Primary Education	World Bank (WDI)
Credit Access	Credit	Population growth rate (annual %)	World Bank (WDI)
Foreign Aid	NODA	Net Official Development Assistance (% of GDP)	World Bank (WDI)
Inclusive Development	IHDI	Inequality-Adjusted Human Development Index	UNDP

WDI: World Development Indicators. WGI: World Governance Indicators. PCA: Principal Component Analysis. UNDP: United Nations Development Program.

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
Educational Quality	43.892	14.775	12.466	100.236	397
Credit Access	19.142	23.278	0.550	149.78	458
Foreign Aid	11.944	14.712	-0.253	181.187	531
Inclusive Development	0.450	0.110	0.219	0.768	431

S.D: Standard Deviation.

Appendix 3: Correlation matrix (uniform sample size: 267)

	Political Governance			Economic Governance			Institutional Governance			G.gov	Openness		Control variables				CO2 mtpc
	PolS	VA	Pol gov	GE	RQ	Eco gov	RL	CC	Inst gov		Trade	FDI	Edu	Credit	NODA	IHDI	
PolS	1.000																
VA	0.710	1.000															
Polgov	0.929	0.920	1.000														
GE	0.687	0.804	0.804	1.000													
RQ	0.673	0.754	0.770	0.894	1.000												
Ecogov	0.699	0.802	0.810	0.976	0.969	1.000											
RL	0.803	0.834	0.885	0.900	0.872	0.919	1.000										
CC	0.713	0.721	0.775	0.853	0.821	0.861	0.868	1.000									
Instgov	0.785	0.805	0.859	0.907	0.876	0.917	0.965	0.965	1.000								
G.gov	0.839	0.883	0.930	0.942	0.915	0.955	0.968	0.912	0.973	1.000							
Trade	0.291	0.094	0.212	0.156	0.085	0.126	0.234	0.219	0.234	0.200	1.000						
FDI	-0.04	-0.05	-0.05	-0.12	-0.18	-0.15	-0.08	-0.11	-0.10	-0.11	0.317	1.000					
Edu	-0.28	-0.30	-0.32	-0.42	-0.37	-0.41	-0.38	-0.39	-0.40	-0.39	-0.36	-0.08	1.000				
Credit	0.338	0.491	0.445	0.575	0.526	0.584	0.519	0.524	0.540	0.550	0.143	-0.10	-0.42	1.000			
NODA	-0.11	-0.02	-0.07	-0.21	-0.26	-0.24	-0.15	-0.17	-0.16	-0.17	-0.01	0.340	0.140	-0.16	1.000		
IHDI	0.458	0.394	0.462	0.608	0.526	0.585	0.552	0.551	0.571	0.567	0.453	0.015	-0.54	0.559	-0.389	1.000	
CO2mtpc	0.356	0.387	0.401	0.557	0.419	0.506	0.454	0.517	0.502	0.494	0.285	-0.02	-0.46	0.712	-0.231	0.651	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.

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