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Enhancing Governance for Environmental Sustainability in Sub-Saharan Africa [1]

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Simplice A. Asongu
Department of Economics,
University of South Africa, P. O. Box 392,
UNISA 0003, Pretoria, South Africa
E-mails: asongusimplice@yahoo.com
/ asongus@afridev.org

Nicholas M. Odhiambo
Department of Economics, University of South Africa,
P. O. Box 392, UNISA 0003, Pretoria, South Africa
E-mails: odhianm@unisa.ac.za / nmbaya99@yahoo.com

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Enhancing Governance for Environmental Sustainability in Sub-Saharan Africa

Simplice A. Asongu & Nicholas M. Odhiambo

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Abstract

This study assesses whether improving governance standards affects environmental quality in 44 countries in sub-Saharan Africa for the period 2000-2012. The empirical evidence is based on Generalised Method of Moments. Bundled and unbundled governance dynamics are used notably: (i) political governance (consisting of political stability and "voice & accountability"); (ii) economic governance (entailing government effectiveness and regulation quality), (iii) institutional governance (represented by the rule of law and corruption-control) and (iv) general governance (encompassing political, economic and institutional governance dynamics). The following hypotheses are tested: (i) Hypothesis 1 (*Improving political governance is negatively related to CO_2 emissions*); (ii) Hypothesis 2 (*Increasing economic governance is negatively related to CO_2 emissions*) and (iii) Hypothesis 3 (*Enhancing institutional governance is negatively related to CO_2 emissions.* Results of the tested hypotheses show that: the validity of Hypothesis 3 cannot be determined based on the results; Hypothesis 2 is not valid while Hypothesis 1 is partially not valid. The main policy implication is that governance standards need to be further improved in order for government quality to generate the expected unfavorable effects on CO_2 emissions.

Keywords: CO_2 emissions; Governance; Economic development; Sustainable development; Africa

JEL Classification: C52; O38; O40; O55; P37

1. Introduction

Assessing how improving governance is relevant to Africa's development is motivated by three main factors, namely: (i) the contemporary concern related to the pollution of the environment; (ii) poor governance issues connected with the management of the policy syndrome of environmental pollution[2] and (iii) gaps in the scholarly literature. The factors are expanded chronologically in the subsequent paragraphs.

First, compared to the past decades, the concern of engaging economic and household activities within an environment that is sustainable is more apparent in the post-2015 development agenda because sustainability of the environment is central to the achievement of Sustainable Development Goals (SDGs). The importance of environmental sustainability which is consistent with contemporary literature is premised on two paramount factors (Akpan et al., 2015; Asongu et al., 2016; Mbah and Nzeadibe, 2016; Asongu et al., 2017), notably, the: (i) appalling energy crisis in Africa and (ii) effects of global environmental pollution. On the one hand, consistent with Shurig (2015), Akinyemi et al. (2015) and Jarrett (2017), about 620 million inhabitants in Africa lack access to "*affordable, reliable, sustainable and modern electricity*". This represents about two-thirds of the population in the continent. Moreover, the underlying crisis is relatively more prevalent in sub-Saharan Africa (SSA) compared to North Africa (IRENA, 2010).

On the other hand, Kifle (2008), Huxster et al. (2015) and Asongu et al. (2017) have argued that the effects of green house gas emissions would be most nefarious in SSA. It is also worthwhile to articulate that the emissions of carbon dioxide (CO_2) represent about three-quarter of the global greenhouse gas emissions (Akpan and Akpan, 2012; Asongu et al., 2018). Furthermore, in accordance with Jarrett (2017), a main impediment to entrepreneurship and doing business in Africa is the lack of power supply. The author further articulates that regular blackouts are experienced by about 30 countries and this predicament accounts for between 2 to 5% loss in annual gross domestic product (GDP). In the nutshell, the deficiency in energy across Africa is detrimental on a number of fronts, *inter alia*, in: job creation, health facilities, education, agricultural transformation and industrial prosperity. Among

[2] With regard to Fosu (2013), a policy syndrome denotes characteristics that are unfeasible for economic development, *inter alia*: "administered redistribution", "state breakdown", "state controls", and "suboptimal inter temporal resource allocation". The underlying notion is understood by Asongu (2017) as a deficiency in knowledge economy while recent inclusive development literature (Asongu and Nwachukwu, 2017a; Tchamyou et al., 2019a) conceive and define it as inequality and/or growth that is not broad-based. Within the context of this research, a policy syndrome is understood to represent environmental degradation.

recommendations to policy makers on the importance of environmental sustainability in achieving SDGs, Jarrett (2017) has emphasized that it is important for governments of concerned countries to enhance governance standards, with a particular focus on how government measures can be designed to improve shared economic development and easy access to affordable, reliable and clean energy. The present research is consistent with the discussed policy insights and recommendations in that, it is focusing on how enhancing governance standards in SSA affect environmental pollution.

Second, SSA is characterized by some of the world's worst energy grid systems and there is an apparent absence of political will to address the energy and environmental issues (Jarrett, 2017). Accordingly, the attendant literature is abundantly clear on the fact that environmental degradation in SSA is substantially traceable to the mismanagement of the environment and energy crisis. Notable studies in this strand include: Odhiambo (2010), Afful-Koomson (2012), Apkan and Akpan (2012), Hongwu (2013), Jones (2003), Chemutai (2009), Odhiambo (2014a, 2014b), Anyangwe (2014), Akinyemi et al. (2015, 2019), Jarrett (2017), Asongu (2018a), Asongu et al. (2018), Efobi et al. (2019) and Asongu and Odhiambo (2019a, 2020a, 2020b). Unfortunately, the highlighted literature, *inter alia*, has failed to assess how improving governance standards affects environmental pollution in the sub-region.

Third, the highlighted gap in the literature builds on the fact that the bulk of attendant studies has largely focused on linkages between environmental pollution, the consumption of energy and economic prosperity. The extant knowledge can be summarized in two main categories. The first which focuses on the linkage between economic growth and environmental pollution is concerned with investigating the Environmental Kuznets Curve (EKC) hypothesis[3]. Some research in this strand include: Diao et al. (2009), Akbostanci et al. (2009) and He and Richard (2010). The second category has two principal dimensions, notably: (i) linkages between energy consumption and the pollution of the environment with some interesting studies from Jumbe (2004), Ang (2007), Apergis and Payne (2009), Odhiambo (2009a, 2009b), Ozturk and Acaravci (2010), Menyah and Wolde-Rufael (2010), Bölük and Mehmet (2015) and Begum et al. (2015) and (ii) nexuses between economic development and needs in energy for production processes in households and corporations, with studies from Mehrara (2007) and Esso (2010)[4].

[3] "The EKC hypothesis is the position that in the long term, there is an inverted U-shape nexus between per capita income and environmental degradation.
[4] "Also see Akinlo (2008) and Olusegun (2008)".

We are cognizant of the risks associated with an empirical exercise that is not supported by clear theoretical underpinnings. However, we argue that an empirical investigation based on policy insights and logical intuition is a useful scientific activity, especially in the light of contemporary development challenges such as environmental sustainability. The intuition for nexuses between governance dynamics and environmental standards are discussed in Section 2. Hence, this research is consistent with the attendant literature supporting the perspective that applied econometrics could be relevant for theory-building and should not be exclusively restricted to the acceptance and rejection of existing theoretical underpinnings (Narayan et al., 2011; Asongu and Nwachukwu, 2016a).

The rest of the paper is structured as follows. Section 2 develops the testable hypotheses in the light of linkages between governance and CO_2 emissions. Section 3 presents the data and discusses the methodology. Section 4 discloses and discusses the results while Section 5 concludes with implications and future research directions.

2. Linkages between governance and CO_2 emissions: hypotheses development

This section develops the arguments supporting the testable hypotheses on nexuses between governance and CO_2 emissions. Consistent with Chemutai (2009), the governance challenges are related to an evolving number of issues in Africa that are connected with among others: food insecurity, economic resources that are inequitably distributed, the scarcity of water, loss of land that is arable, poverty and environmental degradation. The governance issues surrounding environmental mismanagement are apparent because many African nations are severely strained by the underpinning concerns because of among others: the shortage of capacity required to take on board changes resulting from improved international community standards.

As argued by Chemutai (2009), environmental governance policies in Africa need to be considerably overhauled in the light of mainstream standards of environmental protection. Whereas the author has further presented a case for the importance for developed countries in helping those in Africa to improve environmental governance, this research builds on the recommendation to assess how improving governance standards affects the degradation of the environment in SSA.

According to Jones (2003) and Chemutai (2009), given the apparent concerns about governance, African countries have not found it easy to put in place Agenda 21[5]. Furthermore, the implementation of Multilateral Environmental Agreements (MEAs) across the continent has not also been smooth. The documented policy and institutional challenges that generate structures which are inefficient include: the lack of appropriate expertise, shortage of equipments, absence of finance and instruments with which trade policies, corporate unaccountability, environmental protection, international law, *inter alia*, can be enforced. In line with the narrative, for a plethora of motives, environmental policies and standards (e.g. more rigid business accountability policies) are linked with concerns of environmental pollution.

Given the above, environmental issues can be tackled if countries ameliorate their standards in environmental governance. Therefore, tackling apparent weaknesses and constraints in the environmental institutions of the continent is policy-relevant in the post-2015 development agenda. Effective legislation, improved transparency, security and peace, political stability and robustness in procedures of environmental management are crucial for CO_2 emissions to be reduced sustainably across Africa. The concern can be tackled with improved institutional, economic and political channels or instruments. The conception and definition of governance measures adopted within the framework of this study are in line with Andrés et al. (2015) who have built on six governance indicators from the World Governance Indicators of the World Bank. In view of the attendant literature: "(i) political governance (measured with political stability/no violence and "voice & accountability") is the election and replacement of political leaders; (ii) economic governance (entailing government effectiveness and regulation quality) is the formulation and implementation of policies that deliver public goods and services and (iii) institutional governance (proxied by corruption-control and the rule of law) is the respect of citizens and the State, of institutions that govern interactions between them".

Building on the discussed intuition, the testable hypotheses underpinning this research are substantiated in what follows. First, with regard to the prism of political governance, the capacity of the government to prevent environmental degradation can be substantially curtailed by the possibility that elected leaders can be overthrown and governments

[5] "Agenda 21 is a United Nation's voluntarily implemented plan of action that is non-binding with respect to sustainable development".

destabilized by unconstitutional and violent mechanisms. The underlying discourse pertains to the political governance perspective of political stability/no violence. From the angle of "voice and accountability", the ability of the government to put in place measures for effective environmental management can also be constrained by the degree at which citizens of a nation can: (i) effectively participate in the government's selection process and (ii) reap the fruits of free media, freedoms of association and liberty of expression. The following hypothesis can be derived from the narrative on political governance.

Hypothesis 1: Enhancing political governance is negatively related to CO_2 emissions.

Second, as concerns the dimension of economic governance, the pollution of the environment is very likely to be influenced by the effectiveness of the government in implementing policies that are designed to protect the environment, especially in terms of the government's credibility in the formulation and implementation of such policies. Moreover, credible regulation quality is also essential given that with regard to environmental protection, it positively affects the government's ability in: (i) effectively articulating sound measures; (ii) communicating effectively on guidelines and (iii) enforcing rules that enable and foster the development of the private sector. The following hypothesis can be derived from the narrative on economic governance.

Hypothesis 2: Increasing economic governance is negatively related to CO_2 emissions.

Third, from the institutional angle, it is also feasible to argue that institutional governance can affect the effectiveness of the government in implementing measures of environmental protection. This can be evident, contingent on the degree by which: (i) agents abide by and are confident in the rules of society and especially with regard to property rights, contract enforcement, the courts, the police as well as the possibility of violence and crimes (i.e. the rule of law) and (ii) public power is diverted for private interest, including grand forms of corruption, petty thievery and elite capture of the state. The following hypothesis can be inferred from the narrative on institutional governance.

Hypothesis 3: Improving institutional governance is negatively related to CO_2 emissions.

3. Data and methodology

3.1 Data

The present research focuses on 44 SSA nations using data for the period 2000-2012[6]. The data come from two principal sources, notably: (i) World Governance Indicators of the World Bank for the six governance variables and (ii) World Development Indicators of the World Bank for the CO_2 emissions indicator and the control variables. The geographical and temporal scopes of the study are motivated by data availability constraints at the time the study.

The main outcome variable is CO_2 emissions per capita, in accordance with contemporary environmental pollution literature (Asongu, 2018b). The governance indicators from Kaufmann et al. (2010) include: political stability/no violence, voice and accountability, government effectiveness, regulation quality, the rule of law and corruption-control. These exhaustive governance indicators are increasingly being used in the African governance literature. Some recent studies within this framework include: Andres et al. (2015), Efobi (2015), Oluwatobi et al. (2015), Ajide and Raheem, (2016a, 2016b) and Asongu and Nwachukwu (2017b). With respect 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 et al., 2015:1041).

Building on recent CO_2 emission literature (Asongu, 2018b), three main control variables are adopted for the study, namely: Gross Domestic Product (GDP) growth, population growth and education quality. All these variables are expected to positively affect the outcome variable. On the one hand, the anticipated effects from economic prosperity and population growth are logical in the light of the fact that economic development is associated with activities that emit green house gases. Additionally, more people are also expected to

[6] 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".

contribute more towards CO_2 emissions in society. On the other hand, the conception and definition of education quality is in terms of the pupil-teacher ratio. Hence, an increasing ratio translates poor education quality because more people are accommodated by less teaching staff. The choice of primary education quality, relative to variables from higher education quality is motivated by two factors: (i) data availability constraints on variables from higher levels of learning and (ii) the documented comparative importance of primary education when countries are experiencing initial levels of industrialisation. These studies include: Petrakis and Stamakis (2002), Asiedu (2014) and Asongu and Odhiambo (2019b).

The restriction of the research to three control variables is because of the need to avoid instrument proliferation. The use of less control variables in the Generalised Method of Moments (GMM) is not inconsistent with recent literature which has used limited variables in the conditioning information set, notably: no control variable (Osabuohien and Efobi, 2013; Asongu and Nwachukwu, 2017c) and two control variables (Bruno et al., 2012). Appendix 1 provides the definitions and sources of variables; Appendix 2 discloses the summary statistics while the correlation matrix is presented in Appendix 3.

3.2 Methodology

3.2.1 GMM: Specification, identification and exclusion restrictions

Following contemporary literature, the choice of the estimation technique is tailored to be consistent with the data behavior (Kou et al., 2012, 2014, 2016, 2019a, 2019b; Li et al., 2014, 2016; Zhang et al., 2019). The GMM estimation strategy is premised on four foundations as documented in contemporary literature (Tchamyou, 2019, 2020). First and foremost, the number of cross sections being examined substantially exceeds the corresponding periods in each cross section because the research is focusing on 44 countries for 13 years (i.e. 2000-2012). Second, the CO_2 emissions variable is persistent in the light of the fact that the correlation between level and first lag values is higher than the established threshold of 0.800, which is the documented rule of thumb for appreciating persistence in a variable (Tchamyou et al., 2019a, 2019b; Meniago and Asongu, 2018). Third, in the light of the panel data structure, cross-country variations are taken on board in the empirical exercise. Fourth, the empirical exercise is also designed to tackle the issue of endogeneity by accounting for: (i) the unobserved heterogeneity by means of time invariant variables and (ii) reverse causality or simultaneity with a process of instrumentation.

Cognizant of developments in the application of the GMM strategy, the Arellano and Bover (1995) extension of Roodman (2009a, 2009b) is adopted because it has been established in recent literature to reduce the proliferation of instruments (Asongu and Nwachukwu, 2016b; Boateng et al., 2018; Tchamyou et al., 2019a).

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

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

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

where, $CO_{i,t}$ is the CO_2 emissions variable of country i in period t, σ_0 is a constant, σ_1 is the parameter corresponding to CO_2 emissions, G entails governance (political stability, voice & accountability, government effectiveness, regulation quality, rule of law and corruption-control), σ_2 is the parameter corresponding to governance, GG denotes a quadratic interaction between governance dynamics ("political stability" × "political stability", "voice & accountability" × "voice & accountability", "government effectiveness" × "government effectiveness", "regulation quality" × "regulation quality", "corruption-control" × "corruption-control" and "rule of law" × "rule of law"), σ_3 is the parameter corresponding to the quadratic interaction between governance dynamics, W is the vector of control variables (*GDP growth, population growth* and *education quality*), δ_h denotes parameters corresponding to three control variables adopted in the conditioning information set and by implication h varies from 1 to 3 (i.e. δ_1 for GDP growth, δ_2 for population growth and δ_3 for 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.

3.2.2 Identification and exclusion restrictions

The discourse on identification and exclusion restrictions is paramount for robust system GMM estimation. The identification and exclusion restrictions approach adopted in this research is consistent with recent applications of the GMM empirical strategy. These studies include, *inter alia*: Asongu and Nwachukwu (2016c), Tchamyou and Asongu (2017),

Tchamyou (2019, 2020), Boateng et al. (2018), Meniago and Asongu (2018) and Tchamyou et al. (2019b). According to the identification strategy, strictly exogenous variables are considered as time invariant variables whereas the endogenous explaining variables are acknowledged to be predetermined. Roodman (2009b) supports this identification and exclusion restriction approach in the perspective that it is not practical for the adopted strictly exogenous variables to be endogenous after a first difference[7].

Given the discussed identification framework, the exclusion restriction assumption is validated when the alternative hypothesis pertaining to the Difference in Hansen Test (DHT) for instrument exogeneity is rejected. This alternative hypothesis supports the view that the defined strictly exogenous variables affect the dependent variable beyond the engaged predetermined channels. This procedure is consistent with a classical instrumental variable (IV) estimation approach in which the alternative hypothesis of the Sargan test is the position that the adopted instruments do not affect the outcome variable exclusively via the identified endogenous explaining mechanisms (Beck et al., 2003; Asongu and Nwachukwu, 2016d).

4. Empirical results

4. Presentation of results

Table 1 discloses the empirical results. They are presented in three principal categories, each corresponding to a governance dimension, notably: political governance (entailing political stability and voice & accountability); economic governance (consisting of government effectiveness and regulation quality) and institutional governance (encompassing the rule of law and corruption-control). Four main information criteria are used to assess the post-estimation validity of the specifications[8]. Based on these criteria, all the models are overwhelmingly valid because they pass the corresponding post-estimation diagnostic tests.

In order to assess the overall incidence of improving governance on CO_2 emissions, net effects are computed from the estimations. For example, in the third column of Table 1, the net relationship of enhancing "voice & accountability" on CO_2 emissions is 0.075 (2×[0.124 × -0.543] + [0.210]). In the calculation of this net relationship, the mean value of

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

[8] "*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 and De Moor, 2017: 200).

"voice & accountability" is -0.543, the unconditional relationship of "voice & accountability" is 0.210 while the marginal relationship is 0.124. The leading 2 on the first term is from the differentiation of the quadratic term. With the same mode of calculation, in the fifth column of Table 1, the net relationship from enhancing government effectiveness is 0.020 (2×[-0.697 × -0.063] + [-0.067]). In the calculation of this net relationship, the average of "government effectiveness" is -0.697, the unconditional relationship of "government effectiveness" is -0.067 while the marginal relationship is -0.063. Accordingly, the leading 2 on the first term is from the differentiation of the quadratic term.

The significant control variable does not have the expected sign. A reason for the negative nexus between population growth and CO_2 emissions could be traceable to, *inter alia*: (i) population growth not associated with increasing levels of industrialization and productivity, as has been apparent in Africa since political independence in the 1960s and (ii) the fruits of economic prosperity not equitably distributed across the population such that poorer fractions have less to consume and by extension, contribute less towards green house gas emissions. While according to Morris and Fessehaie (2014), Africa's contribution to world trade and global economic prosperity has substantially decreased since independence, recent literature on the poverty tragedy in Africa is consistent with the view that over the past two decades, the fruits of economic prosperity in SSA have not been equitably distributed across the population (Asongu and le Roux, 2017, 2019; Bicaba et al., 2017).

Table 1: Enhancing governance and environmental degradation

	Dependent variable: CO_2 emissions per capita					
	Political Governance (*Hypothesis 1*)		Economic Governance (*Hypothesis 2*)		Institutional Governance (*Hypothesis 3*)	
	Political Stability	Voice & Accountability	Regulation Quality	Government Effectiveness	Rule of Law	Corruption-Control
CO_2 emissions (-1)	**0.908*** (0.000)**	**0.891*** (0.000)**	**0.904*** (0.000)**	**0.928*** (0.000)**	**0.897*** (0.000)**	**0.923*** (0.000)**
Political Stability (PS)	0.036 (0.286)	---	---	---	---	---
Voice & Accountability (VA)	---	**0.210** (0.023)**	---	---	---	---
Regulation Quality (RQ)	---	---	**0.321*** (0.000)**	---	---	---
Government Effectiveness (GE)	---	---	---	**-0.067* (0.082)**	---	---
Rule of Law (RL)	---	---	---	---	**0.184*** (0.002)**	---
Corruption-Control (CC)	---	---	---	---	---	-0.026 (0.261)
PS ×PS	0.006 (0.664)	---	---	---	---	---
VA × VA	---	**0.124*** (0.009)**	---	---	---	---
RQ × RQ	---	---	**0.109*** (0.000)**	---	---	---
GE × GE	---	---	---	**-0.063* (0.080)**	---	---
RL × RL	---	---	---	---	0.015 (0.811)	---
CC × CC	---	---	---	---	---	-0.019 (0.682)
GDP growth	-0.0007 (0.599)	0.0002 (0.773)	-0.0001 (0.884)	-0.001 (0.170)	-0.0003 (0.741)	-0.0005 (0.626)
Population growth	**-0.099*** (0.000)**	**-0.086*** (0.000)**	**-0.074*** (0.000)**	**-0.082*** (0.000)**	**-0.095*** (0.000)**	**-0.090*** (0.000)**
Education	0.0004 (0.733)	0.0001 (0.956)	-0.0004 (0.851)	-0.001 (0.444)	-0.001 (0.529)	-0.0004 (0.729)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Net relationships	na	0.0753	0.1893	0.0208	na	na
AR(1)	**(0.129)**	**(0.129)**	**(0.141)**	**(0.127)**	**(0.128)**	**(0.129)**
AR(2)	**(0.165)**	**(0.172)**	**(0.168)**	**(0.171)**	**(0.167)**	**(0.170)**
Sargan OIR	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Hansen OIR	**(0.732)**	**(0.502)**	**(0.595)**	**(0.193)**	**(0.704)**	**(0.634)**
DHT for instruments						
(a)Instruments in levels						
H excluding group	(0.021)	(0.030)	**(0.128)**	(0.021)	(0.035)	(0.015)
Dif(null, H=exogenous)	**(0.985)**	**(0.830)**	**(0.720)**	**(0.470)**	**(0.952)**	**(0.974)**
(b) IV (years, eq(diff))						
H excluding group	**(0.112)**	**(0.285)**	**(0.188)**	(0.039)	**(0.217)**	**(0.260)**
Dif(null, H=exogenous)	**(0.976)**	**(0.583)**	**(0.792)**	**(0.578)**	**(0.873)**	**(0.761)**
Fisher	**9541.20*** **	**2598.78*** **	**40909*** **	**19557.61*** **	**6043.67*** **	**24201.99*** **
Instruments	32	32	32	32	32	32
Countries	43	43	43	43	43	43
Observations	296	296	296	296	296	296

"*, **, ***: 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. The following are the mean values of governance variables: -0.486 (political stability); -0.543 (voice & accountability); -0.697 (government effectiveness); -0.604 (regulation quality); -0.663 (rule of law) and -0.590 (corruption-control). Constants are included in the regressions".

4.2 Robustness checks

The research further investigates the validity of established findings in Table 1, by bundling the relevant governance variables through principal component analysis. This approach to reducing the dimensions of constituent elements in a governance category is consistent with contemporary studies on Africa's development, notably: Tchamyou (2017) and Asongu and Odhiambo (2019c). The principal component analysis is such that: (i) political stability and voice & accountability are bundled to produce political governance; (ii) government effectiveness and regulation quality are reduced to economic governance and (iii) corruption-control and the rule of law are captured by institutional governance. In addition, a general governance composite indicator is also decomposed from the six governance dynamics.

From the information criteria used to assess the validity of models in Table 1, the models are overwhelmingly valid because they pass all post-estimation diagnostic tests. The results in Table 2 are consistent with those in Table 1 from three main perspectives. (i) Only estimates from regressions related to economic governance are relevant for the computation of nets relationships which are negative. (ii) Enhancing institutional governance does not significantly affect CO_2 emissions, as apparent in the insignificance of its components in Table 1. (iii) Political governance is likely driven by political stability relative to "voice and accountability" because the insignificance of political governance in Table 2 is consistent with the corresponding insignificance in Table 1. By extension, general governance is driven by both political governance and institutional governance given that enhancing general governance does not significantly affect CO_2 emissions. The narrative on the significant control variables is consistent with the discourse on corresponding estimates in Table 1.

Table 2: Robustness checks

	Dependent variable: CO_2 emissions per capita			
	Political Governance (*Hypothesis 1*)	Economic Governance (*Hypothesis 2*)	Institutional Governance (*Hypothesis 3*)	General Governance
CO_2 emissions (-1)	**0.896*** **	**0.904*** **	**0.916*** **	**0.913*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**
Political Governance (Polgov)	0.004	---	---	---
	(0.899)			
Economic Governance (Ecogov)	---	**0.077***	---	---
		(0.052)		
Institutional Governance (Instgov)	---	---	0.032	---
			(0.528)	
General Governance (Ggov)	---	---	---	0.031
				(0.396)
Polgov × Polgov	0.007	---	---	---
	(0.689)			
Ecogov × Ecogov	---	**-0.023** **	---	---
		(0.049)		
Instgov × Instgov	---	---	-0.020	---
			(0.205)	
Ggov × Ggov	---	---	---	-0.010
				(0.229)
GDP growth	-0.0001	-0.001	-0.0007	-0.0001
	(0.902)	(0.122)	(0.506)	(0.900)
Population growth	**-0.102*** **	**-0.088*** **	**-0.088*** **	**-0.092*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**
Education	-0.0004	-0.001	-0.002	-0.002
	(0.833)	(0.282)	(0.330)	(0.230)
Time effects	Yes	Yes	Yes	Yes
Net relationships	na	0.0675	na	na
AR(1)	**(0.134)**	**(0.132)**	**(0.128)**	**(0.129)**
AR(2)	**(0.164)**	**(0.165)**	**(0.169)**	**(0.169)**
Sargan OIR	(0.000)	(0.000)	(0.000)	(0.000)
Hansen OIR	**(0.608)**	**(0.338)**	**(0.815)**	**(0.718)**
DHT for instruments				
(a)Instruments in levels				
H excluding group	(0.046)	(0.091)	(0.031)	(0.054)
Dif(null, H=exogenous)	**(0.866)**	**(0.479)**	**(0.991)**	**(0.925)**
(b) IV (years, eq(diff))				
H excluding group	**(0.233)**	**(0.333)**	**(0.319)**	**(0.261)**
Dif(null, H=exogenous)	**(0.759)**	**(0.349)**	**(0.905)**	**(0.849)**
Fisher	**2961.38*** **	**25587.94*** **	**1977.27*** **	**7643.89*** **
Instruments	32	32	32	32
Countries	43	43	43	43
Observations	296	296	296	296

"*, **, ***: 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. The following are the mean values of governance variables: 0.140 (political governance); 0.205 (economic governance); 0.144 (institutional governance) and 0.284 (general governance). Constants are included in the regressions".

5. Concluding implication and future research directions

This study assesses whether improving governance standards affects environmental quality in 44 countries in sub-Saharan Africa for the period 2000-2012. The empirical

evidence is based on Generalised Method of Moments. Bundled and unbundled governance dynamics are used notably: (i) political governance (consisting of political stability and "voice & accountability"); (ii) economic governance (entailing government effectiveness and regulation quality), (iii) institutional governance (represented by the rule of law and corruption-control) and (iv) general governance (encompassing political, economic and institutional governance dynamics). The following hypotheses are tested: (i) Hypothesis 1 (*Improving political governance is negatively related to CO_2 emissions*); (ii) Hypothesis 2 (*Increasing economic governance is negatively related to CO_2 emissions*) and (iii) Hypothesis 3 (*Enhancing institutional governance is negatively related to CO_2 emissions.*

Results of the tested hypotheses show that: the validity of Hypothesis 3 cannot be determined based on the results; Hypothesis 2 is not valid while Hypothesis 1 is partially not valid. The main implication from the underlying findings is that governance standards need to be further improved in order for government quality to generate the expected unfavorable effects on CO_2 emissions. The recommendation is also logical because governance standards are negatively skewed in the sampled countries (i.e. the standard range is -2.5 to +2.5). Hence, increasing a negative value is more likely to further increase a negative tendency.

In what follows, governance-specific policy implications are discussed. First, as far as political governance is concerned, the corresponding implication is that conditions for the election and replacement of political leaders should be improved substantially. This can be done by, *inter alia*: (i) reducing incidences that can positively affect the likelihood of the governments of sampled countries to be overthrown through violent and unconstitutional mechanisms which may entail terrorism and violence and (ii) ameliorating the degree by which the citizens of countries take part in the selection of government officials as well as enjoy the freedom of association, expression and access to media.

Second, with respect to economic governance, considerable improvements are equally needed in the formulation and implementation of measures and mechanisms that deliver public commodities, which *inter alia*: can reduce CO_2 emissions. For instance, availability of a good public transport system can substantially limit the emission of greenhouse gases. Hence, the government has to be more effective in the provision of public services that are of quality, limitation of political pressures on civil servants, quality of regulations, effective implementation of corresponding regulations and the relevance of credible governments in overseeing the implementation of underlying regulations. Moreover, such policies should also be tailored to favour competition in private sector development because such competition is

necessary to offer citizens with the best options for improving their livelihoods while at the same time reducing their carbon footprints.

Third, on the front of institutional governance, in order for both domestic and foreign stakeholders to have confidence in domestic institutions, both citizens and the governments of sampled countries should respect institutions that govern interactions between them, especially those pertaining to CO_2 emissions. Hence, both citizens and the governments should be sanctioned in accordance with prescribed laws when they fail to respect rules and regulations designed to limit CO_2 emissions. It follows that the rule of law and the control of corruption should be strongly upheld.

It is important to note that the study is recommending that these governance measures should be substantially increased in the sub-region because the unexpected findings could be traceable to the inability of countries in SSA to gain from the time and level hypotheses related to the favourable effects of good governance which, have been independently tested to confirm the existence of a non-linear nexus between democracy and governance quality in developing countries (Sung, 2004; Asongu, 2014). Concerning the level of democracy hypothesis, it has been established that governance quality is highest in states where democracy is strong, average in authoritarian states and least in partly democratised states (Sung, 2004; Back & Hadenius, 2008; Asongu & Nwachukwu, 2016e). The time of exposure hypothesis maintains that young democracies have worse governance standards compared to authoritarian regimes, unlike old democracies which are associated with the best governance standards (Keefer, 2007). These level and time hypotheses are relevant to sub-Saharan Africa because democracies in the sub-region are young and the advent to multiparty politics began for the most part, only after the fall of the Berlin Wall in 1989. It follows that with time, when governance standards are improved in the sub-region, they can be expected to increase environmental quality by means of decreasing CO_2 emissions. Governments in sampled countries can fast-track the process by implementing the recommended policies pertaining political, economic and institutional governance.

Future studies should consider country-specific frameworks because the GMM approach is tailored to eliminate country-specific effects in order to avoid endogeneity owing to the correlation between the lagged outcome variable and country-specific effects. These country-specific studies are worthwhile for targeted policy implications, in the light of some attendant country-specific studies in the literature (Begum et al., 2015; Bölük & Mehmet, 2015).

6. List of Abbreviations

CO_2 emissions: Carbon dioxide emissions
SDGs: Sustainable Development Goals
GDP: Gross Domestic Product
SSA: Sub-Saharan Africa
EKC: Environmental Kuznets Curve
MEAs: Multilateral Environmental Agreements
GMM: Generalised Method of Moments
DHT: Difference in Hansen Test
IV: Instrumental Variable
OIR: Over-identifying Restrictions
WDI: World Development Indicators
WGI: World Governance Indicators
PCA: Principal Component Analysis
PS: Political Stability
VA: Voice and Accountability
Polgov: Political Governance
GE: Government Effectiveness
RQ: Regulation Quality
Ecogov: Economic Governance
RL: Rule of Law
CC: Corruption-Control
Instgov: Institutional Governance
Ggov: General Governance

Appendices

Appendix 1: Definitions of variables

Variables	Signs	Definitions of variables (Measurements)	Sources
CO_2 per capita	CO_2mtpc	CO_2 emissions (metric tons per capita)	World Bank (WDI)
Political Stability	PS	"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
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
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. GDP: Gross Domestic Product.

Appendix 3: Correlation matrix (uniform sample size: 351)

	Governance Dynamics									Control variables				Dependent Variable
	Political Governance			Economic Governance			Institutional Governance							
	PS	VA	Polgov	GE	RQ	Ecogov	RL	CC	Instgov	G.gov	GDPg	Popg	Educ	CO_2mtpc
PS	1.000													
VA	0.711	1.000												
Polgov	0.927	0.923	1.000											
GE	0.677	0.759	0.775	1.000										
RQ	0.627	0.702	0.717	0.883	1.000									
Ecogov	0.637	0.754	0.771	0.974	0.966	1.000								
RL	0.814	0.826	0.886	0.891	0.829	0.888	1.000							
CC	0.719	0.717	0.776	0.858	0.776	0.844	0.867	1.000						
Instgov	0.792	0.798	0.859	0.905	0.830	0.896	0.965	0.967	1.000					
G.gov	0.838	0.871	0.923	0.937	0.886	0.941	0.967	0.914	0.973	1.000				
GDPg	-0.093	-0.007	-0.054	-0.001	-0.079	-0.038	-0.046	-0.063	-0.056	-0.052	1.000			
Popg	-0.333	-0.265	-0.323	-0.406	-0.280	-0.358	-0.376	-0.447	-0.426	-0.392	0.203	1.000		
Educ	-0.355	-0.399	-0.407	-0.395	-0.307	-0.365	-0.417	-0.422	-0.434	-0.425	0.114	0.437	1.000	
CO2mtpc	0.311	0.413	0.391	0.553	0.399	0.496	0.436	0.493	0.481	0.484	-0.078	-0.536	-0.444	1.000

"PS: Political Stability. VA: Voice & Accountability. Polgov: Political Governance. GE: Government Effectiveness. RQ: Regulation Quality. Ecogov: Economic Governance. RL: Rule of Law. CC: Corruption-Control. Instgov: Institutional Governance. Ggov: General Governance. GDP: Gross Domestic Product growth. Popg: Population growth. Educ: Education quality. CO_2mtpc: CO_2 emissions per capita".

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