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The role of Globalization in Modulating the Effect of Environmental Degradation on Inclusive Human Development

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Abstract

This study assesses how globalisation modulates the effect of environmental degradation on inclusive human development in 44 countries in Sub-Saharan Africa (SSA), using data for the period 2000 to 2012. The empirical results are based on the Generalized Method of Moments (GMM). The following main findings are established. First, a trade openness (imports + exports) threshold of between 80-120% of GDP is the maximum level required for trade openness to effectively modulate CO_2 emissions (metric tonnes per capita) and induce a positive effect on inclusive human development. Second, a minimum threshold required for trade openness to modulate CO_2 intensity (kg per kg of oil-equivalent energy use) and induce a positive effect on inclusive human development is 200% of GDP. Third, there is a net positive effect on inclusive human development from the relevance of trade openness in modulating the effect of CO_2 emissions per capita on inclusive human development and a negative net effect on inclusive human development from the importance of trade openness in moderating the effect of CO_2 intensity on inclusive human development.

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

***Keywords*:** CO_2 emissions; Economic development; Africa

1. Introduction

How does globalization modulate the impact of environmental degradation on inclusive human development in sub-Saharan Africa (SSA)? The question motivating this research builds on at least three critical factors in the scholarly and policy literature, notably: (i) the imperative of inclusive development in the post-2015 global development agenda of shared prosperity; (ii) the policy syndrome of environmental degradation in Sustainable Development Goals (SDGs)[1]; (iii) debates over the relevance of globalization in development outcomes; and (iv) gaps in the literature. The factors are expanded in the text that follows.

First, inclusive development is a fundamental policy agenda in the post-2015 development era in SSA because most countries in the sub-region failed to meet the Millennium Development Goal (MDG) common target on halving extreme poverty by 2015 (Asongu & Odhiambo, 2019a, 2019b). The concern of inclusive development is critical in this failure because, despite of achieving more than two decades of resurgence in economic prosperity, about half the countries in the sub-region were unable to reduce extreme poverty to the targeted level (Fosu, 2015; Asongu & Kodila-Tedika, 2017; Tchamyou, 2020, 2019). Moreover, projections are also consistent with the perspective that, if inclusive development is not a fundamental policy priority in the post-2015 era, the global SDG objective of eradicating extreme poverty by 2030 may not be achieved in SSA. A recent study by Bicaba et al. (2017) examined the feasibility of SDG for Sub-Saharan Africa (SSA), the world's poorest but one of the fastest growing regions. Their study found that, "*under plausible assumptions, extreme poverty will not be eradicated in SSA by 2030, but it could be reduced to low levels through high growth and income redistribution towards the poor segments of the society*" (Bicaba *et al.*, 2017,

[1]The concept of "policy syndrome" is multidimensional and complex. It is understood by Asongu (2017a) as a gap in knowledge economy between two countries. Consistent with recent pro-poor development literature (Asongu & Nwachukwu, 2017a; Tchamyou, Erreygers & Cassimon, 2019a), a policy syndrome is considered to be economic development that is broad-based. Within the framework of this study, environmental degradation is considered a policy syndrome.

p. 93). The present research incorporates this narrative by employing inclusive human development as the outcome variable in the light of the global agenda of sustainability in development outcomes.

Second, another dimension of sustainability articulated by SDGs is the need to promote the green economy: the imperative of mitigating environmental risks and scarcities in ecology for sustainable development (Akpan, Green, Bhattacharyya & Isihak, 2015; Asongu, El Montasser, & Toumi, 2016; Mbah & Nzeadibe, 2016; Asongu, le Roux & Biekpe, 2017; Efobi *et al*., 2018). The concepts of sustainability and inclusive development (discussed in the preceding paragraph) are linked in the perspective, according to Amavilah, Asongu and Andrés (2017), that for inclusive development to be sustainable it should be sustained, whereas for sustained development to be sustainable it has to be inclusive.

The premise of environmental sustainability as a concern for SSA has at least two rationales. On the one hand, there is a worrying energy crisis in the sub-region because about 620 million inhabitants (i.e. about two-thirds of the population) lack access to "*affordable, reliable, sustainable and modern electricity*", which is essential in the drive towards SDGs (Shurig, 2015; Akinyemi, Alege, Osabuohien & Ogundipe, 2015; Jarrett, 2017; Akinyemi, Efobi, Asongu & Osabuohien, 2018). On the other hand, the consequences of global environmental pollution and warming have been established to be most detrimental in the sub-region (Kifle, 2008; Huxster, Uribe-Zarain & Kempton, 2015). Furthermore, according to Jarrett (2017), about 30 countries in Africa regularly experience blackouts and the shortage in energy, which is unfavourably affecting businesses in the continent and accounts for approximately 2%–5% loss in annual GDP, *inter alia*, less agricultural transformation, less job creation and lack of socio-economic services.

The present research takes the narrative in this strand on board by adopting carbon dioxide (CO_2) emissions variables as policy syndromes. This is essentially because CO_2 comprises about three-quarters of global greenhouse gas emissions (Akpan & Akpan, 2012; Asongu, le Roux & Biekpe, 2018). Moreover, according to McGrath (2018) and You and Lv (2018) and attendant literature, CO_2 emissions are at an all-time high and globalization (used in this research as a moderating variable) is a determining factor (Emir & Bekun, 2019; Saint Akadiri, Alola, Akadiri & Alola, 2019; Alola, Yalçiner, Alola & Saint Akadiri, 2019a; Alola, Bekun & Sarkodie, 2019b; Bekun & Agboola, 2019; Bekun & Akadiri, 2019; Bekun, Alola & Sarkodie, 2019a ; Bekun, Emir & Sarkodie, 2019b).

Third, the relevance of globalization in development outcomes has been the subject of heated debated in the literature (Prasad & Rajan, 2008; Asongu, 2014a; Price & Elu, 2014; Motelle & Biekpe, 2015; Asongu & Minkoua, 2018). An argument that has been used to motivate the decisions by domestic economies to open their trade and capital accounts is that globalisation increases risk-sharing and efficient allocation of resources, which ultimately leads to the prosperity of nations (Henry, 2007; Kose, Prasad & Taylor, 2011; Asongu, 2017b). However, there have been growing calls in scholarly circles for globalisation to be given an inclusive human face (UN, 2013; Asongu, 2013; Stiglitz, 2007; Kenneth & Himes, 2008). Unfortunately, the attendant literature has not investigated the role of globalization in modulating the influence of CO_2 emissions on inclusive human development.

Fourth, to the best our knowledge, the corresponding literature has fundamentally been articulated along two main strands surrounding nexuses between environmental pollution, energy consumption and economic development. The first strand is concerned with the connection between economic prosperity and environmental degradation, notably: (i) linkages between energy use and environmental pollution (Jumbe, 2004; Ang, 2007;

Apergis & Payne, 2009; Odhiambo, 2009a, 2009b; Ozturk & Acaravci, 2010; Menyah & Wolde-Rufael, 2010; Bölük & Mehmet, 2015; Begum *et al*., 2015) and (ii) nexuses between energy use and economic prosperity (Mehrara, 2007; Esso, 2010; Odhiambo, 2010, 2014a, 2014b). The second strand focuses on testing the Environmental Kuznets Curve (EKC) hypothesis (Diao *et al*., 2009; Akbostanci *et al*., 2009; He & Richard, 2010). The EKC hypothesis is an assumption that, in the long run, there is a non-linear relationship between environmental pollution and income levels.

The present research departs from the underlying literature by focusing on: (i) inclusive human development (i.e. departing from the mainstream literature that has focused on economic growth); and (ii) engaging both policy syndrome and policy variables in assessing how globalisation modulates the effect of CO_2 emissions on inclusive development. This second point is worth articulating further. In the light of the fourth strand discussed in the preceding paragraph, this study argues that it is not enough for studies to simply conclude on linkages between environmental pollution, energy use and development outcomes. This is a common drawback among engaged studies in the fourth strand. This research argues that policy outcomes can be improved if actionable measures are engaged in the empirical analysis, notably through: (i) the involvement of policy variables and policy syndromes; and (ii) computation of policy thresholds at which the policy variables mitigate the policy syndromes to affect the targeted outcome variable. This research takes these concerns on board by providing policy makers with specific actionable globalisation thresholds at which globalisation modulates environmental degradation to promote inclusive development.

The study in the literature closest to the present is Asongu and Odhiambo (2019c) who have concluded that the relationship between CO_2 emissions and inclusive human development in SSA is negative. The authors conclude that "*Based on the robust findings and choice of best estimator, the net*

effect of increasing CO_2 emissions on inclusive human development is negative" (Asongu & Odhiambo, 2019c, p.25). By engaging interactive regressions and providing policy thresholds for the improvement of inclusive development, the current study complements that underlying paper in the light of the identified gaps in mainstream literature discussed in the preceding paragraph.

The positioning of this study also departs from recent inclusive development literature that has focused on, *inter alia*: the relationship between foreign investment and income inequality (Kaulihowa & Adjasi, 2018); nexuses between consumption, income and the wealth of the most poor in SSA (De Magalhães & Santaeulàlia-Llopis, 2018); linkages between corruption and inequality (Sulemana & Kpienbaareh, 2018); gender inequality (Bayraktar & Fofack, 2018; Mannah-Blankson, 2018; Elu, 2018); connections between information sharing, education, finance and inequality (Tchamyou, 2020, 2019); and understanding the poverty tragedy of SSA in the light of dominant paradigms of economic development (Asongu & le Roux, 2019).

The remainder of the study is structured as follows. The theoretical highlights and intuition for the empirics are covered in section 2 while section 3 focuses on the data and methodology. The empirical results are disclosed in section 4. The research concludes in section 5 with implications and future research direction.

2. Theoretical highlights and intuition

The theoretical highlights and intuition are discussed in two main strands, notably: (i) theoretical highlights on the linkage between globalization and inclusive development; and (ii) the intuition motivating the connection between environmental degradation and inclusive development. In the first strand, according to Asongu (2013), there are two main theoretical

connections between globalization and inclusive human development, namely the neoliberal view and hegemonic perspectives.

According to the neoliberal perspective, the phenomenon of globalisation is an ineluctable force of "creative destruction" in the way it influences global trade, innovations in technology, investment across borders and efficiency in production cycles (Tsai, 2006). Hence, despite declining wages for workers who are unskilled and constant replacement of old jobs with new employment opportunities, these inconveniences can be crowded out by the fact that globalisation sends the message to the unemployed and groups with declining wages that there is potential in acquiring new work skills. Consistent with Grennes (2003), the benefits from globalisation can rapidly spread if the labor market responds to variations in supply and demand. Within this strand, Firebaugh (2004) maintains that the globalization project has been tailored to fast-track the process of industrialization in less-developed countries, while Rodrik, Subramanian and Trebbi (2004) posit that international trade improves institutional standards that are relevant in driving economic prosperity in developing countries.

Conversely, the hegemonic view of globalization conceives the phenomenon as a project with a hidden agenda designed to impoverish poor countries and further enrich wealthy nations. Petrasand Veltmeyer (2001) advance that globalization creates a new world architecture in which global powers (i.e. international financial institutions and industrial economies) have, as a fundamental objective, the consolidation of processes that facilitate free market competition and the accumulation of capital. Petrasand Veltmeyer (2001, p. 24) predict "*a world-wide crisis of living standards for labor*", given that most of the unfavorable consequences have affected the working class as "*technological change and economic reconversion endemic to capitalist development has generated an enormous growing pool of surplus labor, an industrial reserve army…with incomes at or below the level of subsistence*". Asongu (2013) argues that the neoliberal project has substantially undermined

the channels that are built with Keynesian social democracy. According to Smart (2003), globalization represents a "market ethos" with a private agenda that disregards the concerns of citizens (Tsai, 2006). This position is broadly shared with *inter alia*: (i) Scholte (2000) on the allocation of fruits from globalization that are skewed in favor of the wealthy segments of society; and (ii) Sirgy, Lee, Millerand and Littlefield (2004), with respect to the negative impacts of globalization. The hegemonic school is also consistent with the substantially documented evidence on the negative effects of globalization on socio-economic development and the environment (Brand & Gorg, 2001; Brand, 2009, 2011, 2012; Brand, Gorg & Wissen, 2011; Brand & Wissen, 2012, 2013; Brand & Gorg, 2008; Jorgenson, 2003, 2007, 2012; Jorgenson, Christopher & Matthew, 2007; Jorgenson, Rice & Clark, 2010; Jorgenson & Clark, 2010, 2012a, 2012b).

The second strand of our intuition is consistent with Asongu and Odhiambo (2019c). This strand argues that environmental pollution is linked to inclusive human development from at least three main perspectives, which are consistent with inherent components of the inequality-adjusted human development index used in this research to proxy for inclusive development. These components are education, health and long life. First, in relation to levels of income, environmental degradation can severely constrain the ability of workers in a household to search for jobs and even work effectively and efficiently when they find work (Zivin & Neidell, 2012). Second, on the front of education, it is logical to think that environmental pollution can substantially affect the decision of parents to send their children to school (Currie, Hanushek, Khan, Neidell, & Rivkin, 2009), especially when there is lack of good transport facilities due to environmental degradation and health concerns that are also associated with such degradation. Moreover, studying at home and at school can be considerably constrained by serious atmospheric pollution (Clark, Crombie, Head, van Kamp, van Kempen & Stansfeld, 2012; Sunyer *et al*., 2015). Third, it follows from the previous narratives

that environmental pollution naturally affects healthy living and consequently, the life expectancy of the population (Rich, 2017; Boogaard, van Erp, Walker & Shaikh, 2017). These insights are broadly consistent with narratives on nexuses between globalization, the human condition and sustainable development in the 21st century (Tausch & Heshmati, 2012; 2013; Tausch, Heshmati & Karoui, 2014).

In view of the above theoretical and intuitive linkages between CO_2 emissions, globalization and inclusive human development, this research also falls within the framework of applied econometrics with a purpose of investigating existing theoretical postulations as well as providing some basis for theory-building. Hence, the research is designed to: (i) accept or reject existing theoretical postulations discussed in the first strand; and (ii) serve as a theory-building exercise based on the intuition discussed in the second strand. Both perspectives are consistent with a recent stream of literature supporting the view that applied econometrics is for theory-building as well as for the acceptance and rejection of existing theoretical underpinnings (Narayan, Mishra & Narayan, 2011; Asongu & Nwachukwu, 2016a).

3. Data and methodology

3.1 Data

The focus of this research is on 44 countries of the SSA region and the corresponding data is for the period 2000-2012[2]. The temporal and geographical scopes are constrained by the availability of data at the time of the study. The data come from three main sources: (i) the inequality-adjusted human development index (IHDI) which is the outcome variable is from the United Nations Development Programme (UNDP); (ii) a control variable (i.e. private domestic credit) is from the Financial Development and

[2]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".

Structure Database (FDSD) of the World Bank and (iii) globalization variables (trade openness and financial openness), environmental degradation indicators (i.e. CO_2 emissions per capita and CO_2 emissions intensity) and three control variables (i.e. education, foreign aid and GDP per capita growth) are from World Development Indicators (WDI) of the World Bank.

The dependent variable which is the IHDI is the human development index (HDI) that is adjusted for inequality. In the light of the corresponding literature: "*The human development index (HDI) denotes a national mean of results in three principal dimensions, notably: health and long life, knowledge and basic living standards. The IHDI goes a step further by adjusting the HDI to prevalent levels of inequality in the aforementioned three dimensions. In other words, the IHDI also takes into consideration the manner in which the three underlying achievements are distributed within the population*" (Asongu *et al*., 2017, p. 355).

In accordance with recent literature (Asongu, 2018a, 2018b): (i) two variables are used to proxy for environmental degradation, namely: CO_2 emissions per capita and CO_2 intensity and (ii) two openness variables are used to also proxy for globalization (trade openness and financial openness). Accordingly, trade openness is imports plus exports (% of GDP) while financial openness is net foreign direct investment (FDI) inflows. The choice of these variables to proxy for trade openness and financial openness is consistent with contemporary globalization literature (Tchamyou, 2017; Asongu, Nnanna & Acha-Anyi, 2020). On the concern of normalizing the globalization variables to account for heterogeneity in the size of countries, this study argues that while there are various ways of normalizing globalization variables, GDP as used by the World Bank is a form of such normalization. Accordingly, the measurement of globalization variables relative to GDP as used in this study is consistent with the attendant contemporary globalization literature. Moreover, among the selected control variables used in the study is GDP per

capita growth which also takes into account country size factors such as GDP and population.

Consistent with recent inclusive human development literature, four control variables are adopted in order to control for variable omission bias, namely: education quality, credit access, foreign aid and GDP per capita growth (Asongu & Odhiambo, 2019a, 2019c; Tchamyou, 2019, 2020; Meniago & Asongu, 2018). This study anticipates that foreign aid and education will decrease inclusive human development whereas credit access and GDP per capita growth will have the opposite effect. First, Asongu (2014b) has used the same IHDI in the assessment of the aid-development nexus to conclude that foreign aid is detrimental to inclusive human development in Africa. Second, the education quality indicator is measured such that it reflects a policy syndrome. Accordingly, an increasing pupils-teacher ratio reflects decreasing education quality because more pupils have to be accommodated by less teaching staff. Third, access to credit has been established by Tchamyou *et al*. (2019a) to promote inclusive development while GDP per capita is a constituent of the IHDI, hence, the expected positive sign. It is also worthwhile the emphasis that education is also a component of the IHDI and its anticipated negative sign in the light of the way it is measured, is consistent with the attendant literature which has established the positive relevance of education in inclusive development (Dunlap-Hinkler, Kotabe & Mudambi, 2010). Moreover, the primary level of education is selected compared to higher education levels for two main reasons. On the one hand, there are issues of degrees of freedom on the variables of higher education. On the other, compared to higher education levels, primary education has been established to be more associated with positive socio-economic development externalities when economies are at the initial phase of industrialization (Asiedu, 2014; Petrakis & Stamakis, 2002; Asongu & Odhiambo, 2018a). 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.

3.2 Methodology

The choice of the estimation approach is consistent with the attendant literature on the need for an empirical strategy to be consistent with the behavior of the corresponding data and problem statement (Kou, Lu, Peng & Shi, 2012; Kou, Peng & Wang, 2014; Kou, Ergu, Chen, Lin, 2016; Kou, Chao, Peng & Alsaadi, 2019a; Kou, Yang, Xiao, Chen & Alsaadi, 2019b; Tchamyou, Asongu & Odhiambo, 2019b). Given that the estimation technique is based on interactive regressions (which are in line with the problem statement), consistent with Asongu and Odhiambo (2020), interactive regressions within the framework of the Generalized Method of Moments (GMM) are used to assess the non-linear nexuses because other panel-based non-linear approaches require a balanced panel data structure, notably: (i) the Panel Threshold Regression (PTR) of Hansen (1999, 2000) and (ii) the Panel Smooth Transition Regression (PSTR) from Gonzalez, Terasvirta and van Dijk (2005) and Gonzalez, Terasvirta, van Dijk and Yang (2017). Hence, the GMM technique is adopted because the panel dataset in this study is unbalanced. It what follows, the consistency of the estimation technique with data behavior as well as attendant advantages is discussed.

3.2.1 GMM: Specification, identification, and exclusion restrictions

The GMM empirical approach is motivated essentially by four principal factors, in accordance with recent literature (Tchamyou, 2020, 2019). First all, the basic premise of having the number of periods in a cross section lower than the corresponding number of cross sections is fulfilled, given that we are engaging forty-four countries over a period of thirteen years (i.e. from 2000-2012). Second, the IHDI is persistent because the correlation between its level and first lag is higher than 0.800, which is the established rule of thumb for assessing persistence (Tchamyou *et al*., 2019a). Third, in the light of the panel

data structure of this study, cross-country differences are taken on board in the estimation exercise. Fourth, the critical concern of endogeneity is also addressed from two principal fronts: (i) reverse causality or simultaneity is accounted for by means of an instrumentation process and (ii) the unobserved heterogeneity is also accommodated with the control for time invariant variables.

The Roodman (2009a, 2009b) extension of Arellano and Bover (1995) is adopted because, compared to standard GMM techniques, it has been established in recent literature to produce more efficient estimates and restrict the proliferation of instruments (Asongu & Nwachukwu, 2016b; Tchamyou *et al*., 2019a; Boateng *et al*., 2018).

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

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

$$\begin{aligned} HD_{i,t} - HD_{i,t-\tau} = {} & \sigma_1 (HD_{i,t-\tau} - HD_{i,t-2\tau}) + \sigma_2 (C_{i,t} - C_{i,t-\tau}) + \sigma_3 (O_{i,t} - O_{i,t-\tau}) + \sigma_4 (CO_{i,t} - CO_{i,t-\tau}) \\ & + \sum_{h=1}^{4} \delta_h (W_{h,i,t-\tau} - W_{h,i,t-2\tau}) + (\xi_t - \xi_{t-\tau}) + (\varepsilon_{i,t} - \varepsilon_{i,t-\tau}) \end{aligned} \quad (2)$$

where, $HD_{i,t}$ is the inclusive human development variable of country i in period t, σ_0 is a constant, C represents a CO_2 emissions variable (CO_2 emissions per capita and CO_2 intensity), O entails globalization (i.e. trade openness and financial openness), CO denotes an interaction between a CO_2 emission variable and an openness proxy ("trade openness" × "CO_2 emissions", "financial openness" × "CO_2 emissions"), W is the vector of control variables (*education, private domestic credit, foreign aid* and *GDP per capita growth*), 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 $\varepsilon_{i,t}$ the error term.

3.2.2Identification and exclusion restrictions

The research devotes space to articulating some elements that are essential in a robust GMM estimation: the identification process and exclusion restrictions. This narrative is consistent with attendant contemporary empirical literature, notably: Asongu and Nwachukwu (2016c), Tchamyou and Asongu (2017), Boateng *et al*. (2018) and Tchamyou *et al*. (2019a). The strategy of identification is such that, time invariant indicators are acknowledged as strictly exogenous while the endogenous explaining indicators are considered as predetermined. This motivation for identification and exclusion restrictions is also supported by Roodman (2009b) who has documented that it is unfeasible for time invariant variables to be endogenous after a first difference[3].

Given the discussed framework of identification, the assumption pertaining to the exclusion restriction is examined with the Difference in Hansen Test (DHT) for instrument exogeneity. Accordingly, the null hypothesis of this test should not be rejected in order for the assumption of exclusion restriction to hold because the null hypothesis is the position that the instruments are valid or that the identified strictly exogenous variables influences the outcome variable exclusively via the endogenous explaining mechanisms. The process of identification is consistent with the standard approach of instrumental variable (IV) estimation in which, the alternative hypothesis of the Sargan test should be rejected in order for the assumption of exclusion restriction to hold (Beck,Demirgüç-Kunt, & Levine,2003; Asongu & Nwachukwu, 2016d).

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

4. Presentation of results

4.1 Empirical results

The empirical findings are provided in Table 1. The presentation of results is divided into two main categories: the left-hand side discloses findings on CO_2 emissions per capita while the right-hand side discloses results of CO_2 emissions intensity. Each of the outcome variables is characterized by four specifications: two on trade-oriented regressions and two on FDI-related estimations. Each openness-related specification has two sub-specifications: one without a conditioning information set (or control variables) and the other with a conditioning information set. It is important to articulate that GMM regressions can be engaged without a conditioning information set. This is consistent with the attendant literature, notably: studies with no control variable (Osabuohien & Efobi, 2013; Asongu & Nwachukwu, 2017b) and research with less than three control variables (Bruno, Bonis & Silvestrini, 2012). In the light of this clarification, the involvement of a conditioning information set can be construed as a form of robustness exercise.

Four main criteria are used to investigate the post-estimation validity of the GMM findings[4]. Based on these criteria, the estimated models are overwhelmingly valid with the exception of the fourth column where the null hypothesis of the Hansen test is rejected. It is worthwhile to articulate that the Hansen (Sargan) test is robust (not robust),but weakened (not weakened) by instrument proliferation. In order to mitigate concerns pertaining to these conflicting criteria, the Hansen test is preferred, and instrument proliferation is avoided by ensuring that the number to instruments does not exceed the number of cross-sections in the specifications. With the exception of the last

[4] *"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 also not weakened by instruments, the Hansen OIR is robust but weakened by instruments. In order to restrict identification or limit the proliferation of instruments, we have ensured that instruments are lower than the number of cross-sections in most specifications. Third, the Difference in Hansen Test (DHT) for exogeneity of instruments is also employed to assess the validity of results from the Hansen OIR test. Fourth, a Fisher test for the joint validity of estimated coefficients is also provided"* (Asongu & De Moor, 2017, p.200).

specification where the instruments exceed the number of cross-sections, the strategy of managing the conflict of interest is overwhelmingly valid.

In light of the motivation of this study, in order to assess the relevance of globalization in modulating the effect of CO_2 emissions on inclusive development, net effects are computed from the unconditional effects of CO_2 emissions and the conditional effects pertaining to the interactive estimate between CO_2 emissions and globalization. As a case in point, the second column of Table 1 shows the net effect of trade openness in CO_2 emissions per capita for inclusive development to be 0.0003 ([76.759× -0.0001] + [0.008]). In this computation, 76.759 is the mean value of trade openness; the unconditional effect of CO_2 emissions per capita is 0.008, whereas the conditional effect from the interaction between CO_2 emissions per capita and trade openness is-0.0001.

Table 1: Globalisation, CO_2 emissions and Inclusive Development

	Dependent variable: Inclusive Human Development (IHDI)							
	CO2mtpc (CO_2 emissions per capita)				CO2inten (CO_2 emissions intensity)			
	Trade Glob. (Trade G)		Financial Glob. (Fin. G)		Trade Glob. (Trade G)		Financial Glob. (Fin. G)	
IHDI(-1)	**0.978*** (0.000)**	**0.934*** (0.000)**	**1.007*** (0.000)**	**0.979*** (0.000)**	**0.972*** (0.000)**	**1.045*** (0.000)**	**0.984*** (0.000)**	**1.026*** (0.000)**
CO2mtpc	**0.008* (0.067)**	**0.012* (0.086)**	-0.0005 (0.717)	0.001 (0.446)	---	---	---	---
CO2inten	---	---	---	---	**-0.006*** (0.000)**	-0.002 (0.769)	**-0.00008** (0.039)**	-0.00007 (0.708)
Trade G.	-0.00005 (0.360)	0.00006 (0.167)	---	---	0.00003 (0.359)	-0.0001 (0.546)	----	---
Fin G.	---	---	**0.0001*** (0.009)**	**0.0003*** (0.000)**	---	---	0.00000 (0.158)	0.00008 (0.854)
CO2mtpc ×Trade G.	**-0.0001** (0.046)**	**-0.0001** (0.024)**	---	---	---	---	---	---
CO2mtpc × Fin G.	---	---	-0.0001 (0.339)	**-0.0004*** (0.000)**	---	---	---	---
CO2inten ×Trade G.	---	---	---	---	**0.00003*** (0.000)**	0.00001 (0.760)	---	---
CO2inten × Fin G.	---	---	---	---	---	---	0.000008 (0.158)	0.000008 (0.843)
Education	---	**-0.0004** (0.018)**	---	0.00002 (0.700)	---	0.000005 (0.985)	---	0.0003 (0.581)
Credit	---	0.0001 (0.184)	---	0.00005 (0.405)	---	-0.0002 (0.502)	---	-0.00004 (0.843)
Foreign Aid	---	**-0.00009** (0.041)**	---	**-0.00008*** (0.000)**	---	0.0004 (0.129)	---	0.0001 (0.675)
GDP pcg	---	**0.0007***	---	**0.0007***	---	0.0002	---	---

		(0.000)		**(0.000)**		(0.239)		
Time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Net effects	0.0003	0.0043	nsa	na	-0.0036	na	na	na
Thresholds	80	120			200			
AR(1)	**(0.134)**	(0.032)	**(0.111)**	(0.020)	**(0.166)**	**(0.925)**	**(0.174)**	**(0.173)**
AR(2)	**(0.510)**	**(0.565)**	**(0.285)**	**(0.563)**	**(0.189)**	**(0.464)**	**(0.852)**	**(0.857)**
Sargan OIR	**(0.504)**	(0.006)	(0.064)	(0.001)	(0.826)	(0.082)	(0.415)	(0.008)
Hansen OIR	**(0.445)**	**(0.516)**	(0.039)	**(0.320)**	**(0.332)**	**(1.000)**	**(0.394)**	**(0.979)**
DHT for instruments								
(a)Instruments in levels								
H excluding group	**(0.266)**	**(0.291)**	**(0.218)**	(0.028)	**(0.407)**	**(0.756)**	**(0.200)**	**(0.143)**
Dif(null, H=exogenous)	**(0.466)**	**(0.592)**	(0.040)	**(0.791)**	**(0.295)**	**(1.000)**	**(0.452)**	**(1.000)**
(b) IV (years, eq(diff))								
H excluding group	---	**(0.184)**	---	(0.020)	---	**(0.870)**	---	**(0.909)**
Dif(null, H=exogenous)	---	**(0.852)**	---	**(0.998)**	---	**(1.000)**	---	**(0.919)**
Fisher	**90964.70 *** **	**19661.97 *** **	**6692.85*** **	**9.30e+06 *** **	**3.65e+07 *** **	**32630.79 *** **	**35627.82 *** **	**2.47e+07 *** **
Instruments	26	37	26	37	26	23	26	37
Countries	41	41	41	41	26	41	26	23
Observations	330	235	341	237	199	139	206	141

*, **, ***: significance levels of 10%, 5% and 1% respectively. *DHT*: Difference in Hansen Test for Exogeneity of Instruments' Subsets. Dif: Difference. *OIR*: Over-identifying Restrictions. The significance of bold values is twofold. 1) The significance of estimated coefficients 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 and Hansen OIR tests. Na: not applicable because at least one estimated coefficient needed for the computation of net effects is not significant. GDPpcg: GDP per capita growth.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 main findings are established from Table 1. There is a net positive effect on inclusive human development from the relevance of trade openness in modulating the effect of CO_2 emissions per capita on inclusive human development while there is a negative net effect on inclusive human development from the importance of trade openness in moderating the effect of CO_2 intensity on inclusive human development. The significant control variables have the expected signs.

4.2 Extension with policy thresholds

In light of the motivation of this research, policy thresholds from established findings are computed in order to provide policy makers with actionable measures that can be implemented to either positively or negatively affect inclusive human development in the sampled countries. The intuition surrounding this threshold notion is consistent with contemporary economic

development literature on, *inter alia,* critical masses for favorable economic consequences (Batuo, 2015; Asongu & Odhiambo, 2019d) and requirements for U-shapes and Kuznets shapes (Ashraf & Galor, 2013).

It is worthwhile to recall that in the computation of net effect, the unconditional effects from the CO_2 emissions (CO_2 intensity) is negative (positive). This is an indication that thresholds can be established at which: (i) enhancing trade reduces inclusive human development by means of CO_2 emissions; and (ii) increasing trade enhances inclusive development by means of CO_2 intensity. Hence positive thresholds (i.e. corresponding to positive conditional effects) and negative thresholds (i.e. corresponding to negative conditional effects) can be computed.

Moreover, given that the outcome variable is a positive economic signal, a positive trade threshold represents a critical mass at which further increasing trade openness has a net positive effect on inclusive human development, while a negative threshold of trade openness implies a critical mass at which further increasing trade openness has a net negative effect on inclusive human development. In the nutshell, thresholds are points where further increasing globalization changes the sign of the unconditional effect of environmental degradation. It is worthwhile to substantiate these perspectives with the empirics of this study. In the second column of Table 1, a threshold of 80 (0.008/ [0.0001]) % of GDP is required for increasing trade openness to have an unfavorable effect of inclusive development. Hence when trade (imports + exports) is at 80 % of GDP, the net effect on inclusive human development is zero ([-0.0001× 80] + [0.008] =0). Therefore, above the established threshold, the net effect on inclusive human development from the association between trade openness and CO_2 emissions per capita is negative. In summary, in order for trade openness to effectively modulate CO_2 emissions per capita in promoting inclusive human development, trade openness should not exceed 80% of GDP. This negative trade openness threshold makes

economic sense and has policy relevance because it is within the range of 20.964 to 209.874 provided in the summary statistics.

Using the same computational analogy, for the net effect established in the right-hand side of Table 1, a positive trade threshold of 200 (0.006/ [0.00003]) % of GDP is required for the trade openness to modulate CO_2 intensity for a positive effect on inclusive human development. It follows that trade (imports + exports) should be at last 200 % of GDP in order for trade openness to effectively dampen the unconditional negative effect of CO_2 intensity on inclusive human development. The threshold is also within policy range.

When the thresholds are compared and contrasted, it becomes apparent that a trade openness threshold of between 80-120% of GDP, is the maximum level required for trade openness to positively affect inclusive human development, while the minimum threshold required for trade openness to positively affect inclusive human development is 200% of GDP. It follows that less trade openness is required for CO_2 emissions (metric tons per capita) not to have an unfavorable effect on inclusive human development than it is required for the unfavorable effect of CO_2 intensity (kg per kg of oil-equivalent energy use) on inclusive human development to be mitigated.

5. Conclusion and future research directions

This study has focused on assessing the how globalization modulates the effect of environmental degradation on inclusive human development in 44 countries in Sub-Saharan Africa using data from 2000 to 2012. The empirical evidence is based on Generalized Method of Moments (GMM). The following main findings are established. First, there is a net positive effect on inclusive human development from the relevance of trade openness in modulating the effect of CO_2 emissions (metric tons per capita) on inclusive human development, while there is a negative net effect on inclusive human development from the importance of trade openness in moderating the

effect of CO_2 intensity (kg per kg of oil-equivalent energy use) on inclusive human development.

When the findings are extended with a threshold analysis, it becomes apparent that a trade openness threshold of between 80-120% of GDP is the maximum level required for trade openness to positively affect inclusive human development, while the minimum threshold required for trade openness to positively affect inclusive human development is 200% of GDP. It follows that less trade openness is required for CO_2 emissions not to have an unfavorable effect on inclusive human development than it is required for the unfavorable effect of CO2 intensity on inclusive human development to be mitigated.

While two globalisation indictors are used in the regressions, only trade-related regressions provide significant findings. Two elucidations can clarify these variations in the relevance of globalisation in modulating the effect of CO_2 emissions on inclusive development, namely: ethical and scholarly insights. From the ethical standpoint, we have decided to report the insignificant FDI-oriented findings in order to avoid the "file drawer" bias in scientific scholarly reporting: the exclusive reporting of expected, significant and strong findings and the consignment of unexpected, insignificant and weak findings to the file drawer (Franco, Malhotra & Simonovits, 2014; Rosenberg, 2015; Boateng *et al*., 2018). In addition, the reporting of FDI-related findings is also in accordance with the perspective that weak and insignificant results also have as much policy relevance and economic significance as strong and significant results. This leads to the scholarly narrative.

Concerning the scholarly elicitation, consistent with the debate surrounding the relevance of globalization in development outcomes discussed in the motivation of this research, it is worthwhile to articulate that the insignificance of the FDI-oriented regressions may be traceable to the fact that there is a

broad consensus in the literature supporting the view that, while the beneficial impacts of trade openness in economic development are apparent, the rewards of financial openness are still not yet apparent, especially in the light of financial crises that have been recurring both in scale and magnitude over the past decades (Prasad & Rajan, 2008; Motelle & Biekpe, 2015; Kose, Prasad & Taylor, 2011; Price & Elu, 2014).

The principal shortcoming of this study is that cross-country-specific effects are not taken on board in the empirical exercise because they are eliminated in order to avoid endogeneity concerns associated with the correlation between the lagged dependent variable and the corresponding country-specific effects. Hence, it will be interesting for future research to assess if the established results in this study are relevant from country-specific settings. Moreover, it would also be worthwhile to take on board alternative measures of globalization such as the KOF globalization measures from Dreher, Gaston, Martens and Van Boxem (2020), which articulate dynamics of social, political and economic globalization. Hence, these KOF indexes of globalization are suggested as future research directions since they measure the social, economic and political dimensions of globalization, while this study focuses on trade openness and financial openness. There is a heated debate on the alternative approaches in empirical globalization research which are also worth engaging in future studies. Steps in this direction can begin with insights into some notable works in this area (Neutel & Heshmati, 2010; Heshmati & Peng, 2012; Tausch & Heshmati, 2012; Heshmati, 2013; Kim & Heshmati, 2019).

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)
CO_2 intensity	CO2inten	CO_2 intensity (kg per kg of oil equivalent energy use)	World Bank (WDI)
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)
Inclusive Development	IHDI	Inequality-Adjusted Human Development	UNDP
Educational Quality	Educ	Pupil teacher ratio in Primary Education	World Bank (WDI)
Credit Access	Credit	Private domestic credit	World Bank (FDSD)
Foreign Aid	NODA	Total Net Official Development Assistance (% of GDP)	World Bank (WDI)
GDP per capita growth	GDPcpg	Gross Domestic Product per capita growth	World Bank (WDI)

WDI: World Bank Development Indicators. WGI: World Governance Indicators. 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
CO_2 intensity	2.089	6.654	0.058	77.586	301
Trade Openness	76.759	35.381	20.964	209.874	519
Financial Openness	5.381	8.834	-6.043	91.007	529
Inclusive Development	0.450	0.110	0.219	0.768	431
Educational Quality	43.892	14.775	12.466	100.236	397
Credit Access	19.142	23.278	0.550	149.780	458
Foreign Aid	11.944	11.944	14.712	-0.253	531
GDP per capita growth	2.302	4.736	-33.983	30.344	530

S.D: Standard Deviation.

Appendix 3: Correlation matrix(uniform sample size: 173)

	CO2 emissions		Openness		Control variables				
	CO2mtpc	CO2inten	Trade	FDI	IHDI	Educ	Credit	NODA	GDPpcg
CO2mtpc	1.000								
CO2inten	0.064	1.000							

Trade	0.202	0.405	1.000						
FDI	-0.078	0.002	0.243	1.000					
IHDI	0.620	0.038	0.459	-0.029	1.000				
Educ	-0.456	-0.084	-0.166	0.123	-0.517	1.000			
Credit	0.786	-0.007	0.169	-0.196	0.607	-0.447	1.000		
NODA	-0.354	-0.097	-0.219	0.148	-0.607	0.489	-0.310	1.000	
GDPcpg	0.155	0.049	0.022	0.136	0.085	-0.005	0.055	0.047	1.000

CO2mtpc: CO_2 emissions (metric tons per capita). CO2inten: CO_2 intensity (kg per kg of oil equivalent energy use). FDI: Foreign Direct Investment.IHDI: Inequality-Adjusted Human Development. Educ: Education quality. Credit: Pivate domestic credit.NODA: Net Official Development Assistance. GDPpcg: Gross Domestic Product per capita growth.

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