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The effect of finance on inequality in Sub-Saharan Africa: Avoidable CO_2 emissions thresholds

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The Effect of Finance on Inequality in Sub-Saharan Africa: Avoidable CO_2 emissions Thresholds [1]

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The Effect of Finance on Inequality in Sub-Saharan Africa: Avoidable CO_2 emissions Thresholds

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Abstract

There is a glaring concern of income inequality in the light of the post-2015 global development agenda of sustainable development goals (SDGs), especially for countries that are in the south of the Sahara. There are also concerns over the present and future consequences of environmental degradation on development outcomes in sub-Saharan Africa (SSA). This study provides carbon dioxide (CO_2) emissions thresholds that should be avoided in the nexus between financial development and income inequality in a panel of 39 countries in SSA over the period 2004-2014. Quantile regressions are used as an empirical strategy. The following findings are established. Financial development unconditionally decreases income inequality with an increasing negative magnitude while the interactions between financial development and CO_2 emissions have the opposite effect with an increasing positive magnitude. The underlying nexuses are significant exclusively in the median and top quantiles of the income inequality distribution. CO_2 emission thresholds that should not be exceeded in order for financial development to continuously reduce income inequality are 0.222, 0.200 and 0.166 metric tons per capita for the median, 75^{th} quantile and 90^{th} quantile of the income inequality distribution, respectively. Policy implications are discussed with particular relevance to Sustainable Development Goals (SDGs).

JEL Codes: H10; Q20; Q30; O11; O55

Keywords: Renewable energy; Inequality; Finance; Sub-Saharan Africa; Sustainable development

1. Introduction

The focus of the present study on assessing carbon dioxide (CO_2) emission thresholds that should not be exceeded in order for financial development to maintain its mitigating role on income inequality is premised on three hypotheses and three tendencies from the policy and scholarly literature. The obvious three hypotheses which are discussed and substantiated in Section 2 are that: (i) financial development reduces income inequality; (ii) CO_2 emissions dampen the underlying negative, or favorable incidence of financial development on income inequality and (iii) the linkages differ in countries with high levels of income inequality compared to countries with low levels of income inequality[2].

The attendant three tendencies which are elaborated in the subsequent paragraphs entail: (i) the glaring concern of income inequality in the light of the post-2015 global development agenda of sustainable development goals (SDGs), especially for countries that are south of the Sahara; (ii) issues over the present and future consequences of environmental degradation on development outcomes in sub-Saharan Africa (SSA) and (iii) gaps in the literature on nexuses between income inequality, financial development and CO_2 emissions. These three tendencies are expatiated in the same chronology as highlighted in the passages that follow.

First, SDG 10, which consists of reducing cross-country inequality in the world, is linked to most other SDGs because their attainments are contingent on the reduction of poverty and inequality (Harsch, 2018). Moreover, the main variables of interest in this study are related to the three main aspects of sustainable development, notably, the social, economic, and environmental dimensions which are broadly encapsulated in inequality, financial inclusion (within the framework of financial development) and environmental degradation in terms of CO_2 emissions.

Second, the consequences of environmental degradation have been documented to be the most detrimental in SSA owing to a plethora of reasons, including (i) most of the worst systems of electricity grid in the world are located in the sub-region (Asongu, Iheonu & Odo, 2019; Jarrett, 2017) and (ii) the unfavorable ramifications of climate change would be the most disastrous in SSA according to Asongu and Odhiambo (2020a, 2020b). In the light of the attendant literature, an illustration that is worthwhile in putting the highlighted concerns into perspective is the fact that the production of electricity in the sub-region is almost equivalent to that produced by a single state in the United States of America (USA) such as

[2] "Income inequality" and inequality are used interchangeably throughout the study. Financial inclusion, financial access and financial development are also used interchangeably throughout the study.

New York. Moreover, the literature is also sympathetic to the position that the principal economic development challenges in Africa are surrounded by issues of climate change, degradation of the environment, lack of inclusive development, limited funding and low development of the financial sector.

Some notable studies supporting the above perspectives are Asongu, Biekpe and le Roux (2017, 2018), Nathaniel and Iheonu (2019), Asongu and Odhiambo (2019a, 2019b), Akinyemi, Efobi, Asongu and Osabuohien, (2019), Nathaniel and Bekun (2020), Joshua and Alola(2020), Asongu, Agboola, Alola and Bekun (2020) and Joshua, Bekun and Sakordie (2020). In spite of these documented concerns on the relevance of sustainable environmental management in Africa, the literature on nexuses between inequality, CO_2 emissions, and financial development is sparse. This study integrates the three critical dimensions (income inequality, financial development and environmental pollution) discussed so far by assessing critical masses of CO_2 emissions that dampen the potential favorable incidence of financial development in decreasing inequality due to an apparent gap in the scholarly literature.

Third, the positioning of this study in the light of attendant literature is situated within two strands of the literature pertaining to the nexuses between financial development and CO_2 emissions. According to the first strand, environmental degradation is positively related with financial development because CO_2 emissions are positively linked to such financial development. The stream of studies supporting the underlying nexus included: Zhang (2011), Boutabba (2014), Al-Mulali, Ozturk and Lean (2015), Shahbaz, Shahzad, Ahmad and Alam (2016), Bekhet, Matar and Yasmin (2017), Ali et al. (2018), Lu (2018) and Cetin, Ecevit and Yucel (2018). Conversely, the contending perspective in the literature posits that financial development and environmental sustainability are negatively related, mentioned in the studies of Jalil and Feridun (2011), Shahbaz, Tiwari and Nasir (2013), Tamazian, Chousa and Vadlamannati (2009),Tamazian and Rao (2010), Omri, Daly, Rault and Chaibi (2015),Dogan and Seker (2016), Saidi and Mbarek (2017), Xing et al. (2017), Xiong and Qi (2018), Zafar, Saud and Hou (2019) and Zaidi, Zafar, Shahbaz and Hou (2019).

The present study leverages on the second stream of the attendant literature to establish a hypothetical negative nexus between financial development and CO_2 emissions on which the outcome of inequality is contingent. In other words, the research aims to investigate how CO_2 emissions mitigate the potential favorable incidence of financial development in reducing income inequality. Accordingly, the positive relevance of financial inclusion in promoting inclusive development and reducing income inequality is documented in

contemporary inclusive development literature (Tchamyou, 2019a, 2019b; Tchamyou, Erreygers & Cassimon, 2019a).

The study in the literature which is the closest to this paper is Odhiambo (2020). The comparative research examines how inequality affects the negative nexus between financial development and CO_2 emissions. By extension, the study provides income inequality thresholds that dampen the positive relevance of financial development in reducing CO_2 emissions.

The present study departs from Odhiambo (2020) by investigating how CO_2 emissions affect the negative nexus of financial development on income inequality and by extension, provides CO_2 emissions thresholds that should not be exceeded in order for the underlying favorable effect of financial development on reducing income inequality to be maintained. Moreover, while Odhiambo (2020) uses the Generalized Method of Moments (GMM), quantile regressions are considered in the present study to articulate all the conditional distribution of income inequality. It follows that contrary to Odhiambo (2020) in which nexuses are investigated at the mean value of the CO_2 emissions outcome variable, the present study examines the attendant nexuses throughout the conditional distribution of the inequality outcome variable.

Before engaging theoretical underpinnings relevant for the derivation of the testable hypotheses, it is important to note that the above positioning fundamentally departs from the two main dominant strands of environmental sustainability and pollution literature. The first on nexuses between economic prosperity and environmental pollution involves studies such as Layachi (2019), Bah, Abdulwakil and Azam (2020), Magazzino, Bekun, Etokakpan and Uzuner (2020) and Nathaniel, Barua, Hussain and Adeleye (2020), whereas the second strand on linkages between environmental pollution and energy consumption entails studies of Wang and Dong(2019), Adams and Nsiah (2019),Nathaniel and Iheonu (2019), Akinyemi, Efobi, Osabuohien and Alege (2019), Acheampong, Adams and Boateng (2019) and Kuada and Mensah (2020).

The rest of the study is organized as follows. The theoretical underpinnings supporting the testable hypotheses are covered in Section 2, while Section 3 discusses the data and methodology. The empirical findings and corresponding discussion are engaged in Section 4. Section 5 concludes with implications and future research directions.

2. Theoretical underpinnings and testable hypotheses

This section aims to substantiate the three main hypotheses underpinning this study which are clarified in the introduction, notably: (i) the negative relationship between financial development and income inequality; (ii) the role of CO_2 emissions in dampening the underlying negative nexus and (iii) differences in the responses in terms of initial levels of income inequality. The three strands are expanded in the same chronology as they are highlighted.

First, the premise for a negative nexus between financial development and CO_2 emissions fundamentally is based on Tchamyou, Erreygers and Cassimon (2019a), who document two theoretical perspectives on the association between financial development and outcomes of economic and human developments. According to the first standpoint, financial development mitigates income inequality whereas the second perspective maintains that financial development cannot engender positive microeconomic and macroeconomic externalities because concerns of information asymmetry abound that restrict access to finance needed for investment and economic prosperity (Kusi & Opoku-Mensah, 2018; Kusi, Agbloyor, Ansah-Adu & Gyeke-Dako, 2017; Kusi, Agbloyor, Gyeke-Dako & Asongu, 2020).

The main argument in the underlying second perspective of literature posits that financial development is more skewed in favour of the rich in society because wealthy elements of society are characterized by the collaterals needed to have access to credit in banks (Asongu, Nwachukwu & Tchamyou, 2016; De Haan & Sturm, 2017; von Fintel & Orthofer, 2020)[3]. It is fundamentally for this reason that elements of the poor fraction of society largely depend on the non-formal and informal economic sectors and remittances for financial access (Ssozi & Asongu, 2016; Beck, Demirgüç-Kunt & Levine, 2007). Of the contending perspectives discussed, the former is more aligned with the objectives of this study because it posits that financial development is more likely to reduce income inequality, leading to the first testable hypothesis of the present study.

H1: Financial development reduces income inequality

To bring on board a non-linear perspective to the narrative, in what follows, the study posits that the underlying negative relationship of financial development (in the perspective of financial access) can be constrained by environmental degradation (in the perspective of CO_2 emissions). To make this feasible, the study shows that environmental degradation and

[3] It is also important to note that the association between financial development and income inequality in this study is broadly consistent with a non-contemporary strand of literature on the nexus between financial development and income inequality (Galor & Zeira, 1993; Galor & Moav, 2004; Aghion & Bolton, 2005).

financial development have a negative association. In essence, there is a bulk of literature supporting the view that environmental degradation, including CO_2 emissions, is negative for development outcomes (entailing financial access). This substantial bulk of the literature includes: (i) the incapacity of parents to send their kids to school owing to environmental pollution, lack of good transport facilities, and the financial inability of parents to transfer their kids to other educational facilities that are less affected by the consequences of environmental degradation (Currie, Hanushek, Khan, Neidell & Rivkin, 2009).

(ii) CO_2 emissions can also influence the capacity of students to effectively learn in class, probably because the schools are neither located in pollution-free environments nor equipped with systems that absorb negative ramifications of environmental pollution (Clark et al., 2012; Sunyer et al., 2015); (iii) an increase in financial inclusion owing to financial development can improve possibilities of citizens to have better health care facilities as well as enhance odds of life expectancy of the attendant population (Rich, 2017; Boogaard, van Erp, Walker & Shaikh, 2017);

(iv) The income of the family can be affected by environmental degradation especially when environmental pollution reduces the prospects of workers in the family to find decent jobs (Zivin & Neidell, 2012) and by extension, access to formal bank accounts which can enable them to get credit for investment purposes. The underlying literature motivates the hypothesis that CO_2 emissions mitigate a plethora of development outcomes, among which is financial development. Moreover, the resulting hypothesis is built on the fact that the discussed nexuses between environmental degradation are linked ex-ante and ex-post to inequalities among families which can be addressed by more financial inclusion or financial development.

H2: CO_2 emissions dampen the favourable or negative incidence of financial development on income inequality.

The above hypothesis is consistent with the position that the nexus between financial development and socio-economic development can be non-linear (Greenwood & Jovanovic, 1990; Asongu & Tchamyou, 2014). The moderating variable emphasizing the non-linear dimension in *H2* is CO_2 emissions. Moreover, the two hypotheses are tested throughout the conditional distribution of the outcome variable or inequality, such that estimated coefficients emphasize countries with low, intermediate and high existing levels of income inequality to increase room for policy implications, consistent with the motivation of the study. This motivates the third testable hypothesis.

H3: Compared to countries with high inequality levels, countries with low income

inequality levels respond differently to interactions between CO_2 and financial development.

An estimation that enables the study to account for initial levels of income inequality is the quantile regressions strategy which is designed to control for various levels of the outcome variable or income inequality in the relationships between financial development and CO_2 emissions (Koenker & Bassett, 1978; Koenker, 2005; Hao & Naiman, 2007; Asongu, 2013). Hence, the estimation approach takes on board, low, intermediate, and high initial levels of income inequality.

3. Data and methodology

3.1 Data

This study uses a panel of 39 countries in SSA from 2004-2014[4].The periodicity of the study is because of constraints in the availability of data at the time of the study to assess the testable hypotheses documented in the previous section. The attendant data are obtained from four principal sources, notably: (i) the Global Consumption and Income Project (GCIP) for the inequality variable. Inequality is measured with the Gini Coefficient which reflects the distribution of income in a country. Whereas a coefficient of 1 reflects the perfect inequality, a coefficient of 0 is a situation where there is an absence of inequality such that everyone has the same amount of income. This choice of the Gini coefficient as an indicator of inequality is motivated by contemporary income inequality literature (Naceur & Zhang, 2016; Meniago & Asongu, 2018; Tchamyou, 2019a, 2019b).

(ii) The moderating or environmental degradation variable which is proxied by CO_2 emissions (metric tons per capita) is obtained from the World Development Indicators (WDI) of the World Bank and informed by contemporary CO_2 emissions literature (Asongu, 2018a, 2018b; Odhiambo, 2020). (iii)The financial development channel is proxied by a financial access variable that captures both informal and non-formal financial sectors of the economy to reflect those excluded from formal banking institutions that rely on the non-formal financial sector, namely: “private domestic credit from deposit banks and other financial institutions”. The variable is from the Financial Development and Structure Database (FDSD) of the World Bank.

[4] The 39 sampled countries are: Angola; Benin; Botswana; Burundi; Cabo Verde; Cameroon; Central African Republic; Chad; Comoros; Congo Democratic Republic; Congo Republic; Cote D’Ivoire; Eswatini; Gabon; Gambia; Ghana; Guinea; Guinea-Bissau; Kenya; Lesotho; Liberia; Madagascar; Malawi; Mali; Mauritius; Mozambique; Namibia; Niger; Nigeria; Rwanda; Sao Tome and Principe; Senegal; Seychelles; Sierra Leone; South Africa; Sudan; Tanzania, Togo and Uganda

It is relevant to further articulate the connection between financial access and the poor because: (i) financial access is the main channel; (ii) inequality is the outcome variable; (iii) financial access is anticipated to unconditionally reduce inequality as apparent in *H1* and (iv) most of the poor in developing countries are connected with the non-formal financial sector compared to the formal financial sector. As apparent in Appendix 1 from Asongu and Acha-Anyi (2017), other financial institutions in the definition of financial access entail financial establishments that are registered but not licensed by the government and central bank, notably: institutions of microfinance; micro businesses and credit unions that involve the entrepreneurial poor fraction of the population.

Seven control variables are involved in the estimation exercise to account for variable omission bias, namely: (i) political stability from the World Governance Indicators (WGI) of the World Bank; (ii) mobile phone penetration, trade openness, urban population, remittances and middle income from WDI of the World Bank and (ii) petroleum-exporting countries from Asongu, Nwachukwu and Pyke (2019). The first-five variables are non-dummy variables, while the last-two are dummy variables. Moreover, the choice of the control variables is informed by contemporary inclusive development literature (Tchamyou et al., 2019a, 2019b; Asongu & Odhiambo, 2019c). It what follows, the expected signs are discussed.

First, information and communication technology is established to be associated with inclusive development outcomes (Gosavi, 2018; Humbani & Wiese, 2018; Issahaku, Abu & Nkegbe, 2018; Lashitew, van Tulder & Liasse, 2019). Second, political stability is anticipated to averagely reduce income inequality because a conducive political environment that is characterized by political stability and no violence provides enabling conditions for investment, employment, upward social mobility, and safety income nets that benefit the poor and by extension, contributes towards a reduction of income inequality. Third, trade openness is likely to reduce income inequality within the context of CO_2 emissions because trading activities also offer avenues of employment and social mobility for the poor. Moreover, Asongu and Odhiambo (2020c) show that net positive effects on inclusive human development are apparent from the relevance of trade openness in interactions between CO_2 emissions and inclusive human development.

Fourth, the urban population is likely to increase income inequality because if economic prosperity is not associated with the equitable distribution of the fruits of the attendant economic prosperity, especially with a growing urban population that is mostly traceable to poor households, an increasing urban population can be associated with higher income inequality. This is the situation with SSA that experiences more than two decades of

resurgence in economic growth, a burgeoning urban population and the inequitable distribution of fruits of economic prosperity, which is partly why about 50% of countries in the sub-region fail to reach the millennium development goal target of halving extreme poverty (Tchamyou, 2020a).

Fifth, the effect of remittances on inequality is contingent on what proportion of those migrating abroad is from rich households versus poor households (Anyanwu, 2011; Tchamyou et al., 2019a). Hence, the potential incidence cannot be established with certainty especially in the light of the fact that, in this study, the outcome variable (income inequality) is being assessed so that existing levels of income inequality are taken on board.

Sixth, whereas the effects of income levels and petroleum-exporting countries depend on the weight of these countries in the sample, the general tendency that most countries did not achieve the MDG extreme poverty target owing to inequality (Tchamyou, 2020a, 2020b) can explain an expectation of a negative relationship between the two dummy variables and the outcome variable, given that middle income and petroleum-exporting countries are comparatively wealthier than low income countries and resource-poor countries, respectively. Since the discussed nexuses are assessed throughout the conditional distribution of inequality, the expected signs cannot be significant throughout the conditional distribution of income inequality owing to specificities in respective quantiles of the income distribution. Appendix 1, Appendix 2 and Appendix 3 disclose the definitions and sources of variables, the summary statistics and correlation matrix, respectively.

3.2 Methodology

In the light of the motivation of this study which is to assess the attendant nexuses throughout the conditional distribution of income inequality, this study employs quantile regressions for the purpose of investigating how interactions between financial development and CO_2 emissions affect income inequality when existing levels of income inequality are low, intermediate and high. It is important to note that the emphasize throughout the conditional distribution of income inequality is motivated by the perspective that blanket policies based on mean values of income inequality are less likely to be policy-relevant unless initial levels of income inequality are taken on board to articulate findings that are worthwhile to specificities of countries at different levels of income inequality.

The choice of the quantile regression approach is also informed by the extant non-contemporary and contemporary studies on the importance of adopting the empirical strategy to articulate countries with different levels of the outcome variable (Koenker & Bassett, 1978;

Tchamyou & Asongu, 2017). The justification is also consistent with studies which acknowledge robustness of the technique in providing conditional findings, compared to alternative techniques based on mean values of the outcome variable that provide findings with blanket policy implications (Koenker, 2005; Okada & Samreth, 2012; Hao & Naiman, 2007; Asongu & Odhiambo, 2019d).

In Equation (1) below, the θ^{th} quantile estimator of income inequality is derived by analyzing the following problem which is presented without subscripts for the purpose of simplicity

$$\min_{\beta \in R^k} \left[\sum_{i \in \{i: yi \geq xi'\beta\}} \theta \left| yi - xi'\beta \right| + \sum_{i \in \{i: yi < xi'\beta\}} (1-\theta) \left| yi - xi'\beta \right| \right], \quad (1)$$

where $\theta \in (0,1)$. Contrary to the Ordinary Least Squares (OLS) approach that is premised on minimizing the total of residuals that are squared, with Quantile regressions, the focus is on minimizing the weighted total of absolute deviations. As cases in point, the 10th and 75th quantiles (corresponding respectively to θ=0.10 and θ=0.75) are assessed by weighing the residuals approximately. The conditional quantile of income inequality or y_i given x_i is:

$$Q_y(\theta / x_i) = x_{i'}\beta_\theta \quad (2)$$

where parameters with unique slopes are assessed for each θ^{th} specific quantile. Accordingly, Equation (2) is analogous to $E(y / x) = x_{i'}\beta$ in the OLS slope for which the examined parameters are assessed throughout the conditional distribution of income inequality. It follows from the equation that the dependent variable y_i is income inequality while x_i contains: a constant term, CO_2 emissions, financial access, mobile phone penetration, political stability, trade openness, urban population, remittances, middle income countries, and petroleum-exporting nations.

4. Empirical results

4.1 Presentation of results

The empirical results are presented in Table 1 in this section. The first column discloses the variables and information criteria; the second column shows OLS results while the last-five columns provide the quantile regression findings in increasing order of inequality. It is important to note that from the left-hand side to the right-hand side, inequality increases accordingly, following the fact that at the 10th quantile, income inequality is least whereas at the 90th quantile, income inequality is most. When the OLS and quantile regressions estimates are compared, the apparent distinctions in terms of significance and

magnitude of significance justify the choice of this quantile regressions approach which assesses the investigated linkages throughout different levels of inequality.

The following findings are established with the tested hypotheses. First, *H 1* is valid because financial access unconditionally reduces income inequality and the mitigating effect increases in magnitude with increasing levels of income inequality in the top quantiles of the income inequality distribution. Second, *H2* is also valid because CO_2 emissions dampen the mitigating effect of financial access on inequality owing to the corresponding positive interaction effects that consistently increase in magnitude with increasing levels of income inequality in the top quantiles of the income inequality distribution. Third, *H3* is also valid because *H1* and *H2* are exclusively valid in the median and top quantiles of the income inequality distribution. The attendant hypothesis is proved to be valid because compared to countries with high inequality levels, countries with low income inequality levels respond differently to interactions between CO_2 and financial development. Most of the significant control variables have the expected signs, in accordance with the narrative in the data section.

Hence, CO_2 emissions (metric tons per capita) thresholds that should not be exceeded in order for financial development to continuously reduce income inequality are computed to increase room for policy implications. The attendant thresholds are 0.222 (0.0002/0.0009), 0.200 (0.0004/0.002) and 0.166 (0.0005/0.003) metric tons per capita, for the median, 75^{th} quantile and 90^{th} quantile of the income inequality distribution, respectively. The threshold in the 75^{th} quantile is computed as the unconditional effect of financial access (0.0004) divided by the conditional or interactive effect between financial access and CO_2 emissions (0.002). Abstraction is made of the signs of both effects during the computation, and the thresholds are considered as positive thresholds because they translate how the sign of the unconditional effect (which is negative) changes to the sign of the corresponding the conditional effect (which is positive).

Table 1: Financial development, CO_2 emissions and Inequality

	Dependent Variable: The Gini Coefficient					
	OLS	Q.10	Q.25	Q.50	Q.75	Q.90
Constant	**0.592*** **	**0.565*** **	**0.580*** **	**0.588*** **	**0.600*** **	**0.603*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
CO_2 emissions	-0.001	**0.006***	0.005	0.003	-0.004	**-0.007*** **
	(0.670)	**(0.098)**	(0.286)	(0.412)	(0.258)	**(0.000)**
Financial Access	**-0.0003*** **	-0.00006	-0.0001	**-0.0002** **	**-0.0004*** **	**-0.0005*** **
	(0.000)	(0.458)	(0.233)	**(0.024)**	**(0.000)**	**(0.000)**
CO_2 emissions × Financial Access	**0.002*** **	0.0003	0.0006	**0.0009** **	**0.002*** **	**0.003*** **
	(0.002)	(0.497)	(0.289)	**(0.049)**	**(0.000)**	**(0.000)**
Mobile Phone	**-0.0003*** **	**-0.0002*** **	**-0.0002** **	**-0.0001*** **	-0.00004	**-0.0001*** **
	(0.000)	**(0.001)**	**(0.010)**	**(0.005)**	(0.447)	**(0.000)**
Political Stability	**-0.003** **	-0.0005	-0.001	-0.003	0.001	-0.001
	(0.043)	(0.834)	(0.565)	(0.153)	(0.536)	(0.115)
Trade Openness	**-0.0001*** **	**-0.0001** **	-0.0001	**-0.0001** **	-0.00008	-0.00003
	(0.000)	**(0.013)**	(0.116)	**(0.046)**	(0.134)	(0.212)
Urban Population	**0.0007*** **	**0.001*** **	0.0004	0.0002	0.0003	**0.0003** **
	(0.008)	**(0.000)**	(0.235)	(0.434)	(0.147)	**(0.015)**
Remittances	-0.00008	-0.0001	-0.00006	0.00006	**-0.001*** **	**-0.001*** **
	(0.801)	(0.773)	(0.909)	(0.890)	**(0.008)**	**(0.000)**
Middle Income	**-0.010** **	0.002	0.002	0.003	**-0.014*** **	**-0.016*** **
	(0.015)	(0.657)	(0.762)	(0.570)	**(0.002)**	**(0.000)**
Petroleum Exporting	**-0.038*** **	**-0.080*** **	**-0.058*** **	**-0.032*** **	**-0.012** **	**-0.012*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.027)**	**(0.000)**
Thresholds	0.1500	na	na	0.2222	0.2000	0.1666
Pseudo R^2/R^2	0.701	0.440	0.314	0.311	0.429	0.666
Fisher	**17.72*** **					
Observations	222	222	222	222	222	222

*,**,***: significance levels of 10%, 5% and 1% respectively.. Lower quantiles (Q 0.1) signify nations where inequality is least. na: not applicable because at least one estimated coefficient needed for the computation of thresholds is not significant.

4.2 Implications for sustainability

Before concluding, it is worthwhile to clarify why the concern of inequality addressed in this study is vital on the one hand, and on the other hand, how the computed CO_2 emission

thresholds are particularly relevant for economic development in Africa in the light contemporary literature on sustainability. First, the concern of inequality is particularly preoccupying in SSA because most countries in the sub-region experienced considerable growth resurgence from the mid 1990s but failed to reduce the number of people living in extreme poverty by a half in the light of the millennium development goal extreme poverty target (Tchamyou, 2019a, 2019b).

Furthermore, current projections are established that for the SDG of reducing extreme poverty to a critical threshold of about 3% by 2030 to be achieved, reduction of income inequality to improve the responsiveness of poverty reduction to economic growth is worthwhile (Bicaba, Brixiova & Ncube, 2017). On the front of environmental sustainability, policy makers and scholars are also in accordance with the fact that the consequences of CO_2 emissions would be most detrimental in Africa and, hence, CO_2 emissions reduction should be a priority in the region to limit the corresponding negative consequences of global warming (Asongu, El Montasser & Toumi, 2016; Mbah & Nzeadibe, 2016).

The challenges of income inequality and environmental sustainability are central to SDGs in the post-2015 global development agenda. The findings of this study are relevant to policy makers on both fronts, notably because since a policy framework that is focused on reducing income inequality is achieved based on the validated tested hypotheses, the computed CO_2 emission thresholds which can enable the mitigation of income inequality also provide policy makers with actionable policy critical masses that should be considered in view of promoting the sustainability of the environment.

Moreover, the fact that the CO_2 emission thresholds decrease with increasing levels of income inequality is another indication that *ceteris paribus*, CO_2 emissions can be kept at a minimum to exert the maximum favorable effects of reducing inequality by means of financial access, especially with increasing levels of income inequality. Furthermore, the financial access proxy used in this study is tailored to capture both the formal and non-formal financial sectors of the economy. Hence, policy makers should focus on enhancing financial access both in the formal and non-formal financial sectors of the economy to better reduce income inequality for the achievement of most SDGs that are inequality-oriented.

5. Conclusion and future research directions

This study provides carbon dioxide (CO_2) emissions thresholds that should be avoided in the nexus between financial development and inequality in a panel of 39 countries in Sub-Saharan Africa over the period 2004-2014. Quantile regressions are used as the empirical

strategy. The following findings are established. Financial development unconditionally decreases income inequality while the interactions between financial development and CO_2 emissions have the opposite effect. The underlying nexuses are significant exclusively in the median and top quantiles of the income inequality distribution. CO_2 emission thresholds that should not be exceeded in order for financial development to continuously reduce income inequality are 0.222, 0.200, and 0.166 metric tons per capita for the median, 75^{th} quantile and 90^{th} quantile of the income inequality distribution, respectively. Policy implications have been discussed with particular relevance to Sustainable Development Goals (SDGs).

The relevance of the findings to SDGs is discussed in terms of concerns about reducing income inequality and promoting environmental sustainability. Accordingly, the established CO_2 emission thresholds, which can enable the mitigation of income inequality also provide policy makers with actionable policy critical masses that should be considered to promote environmental sustainability. The findings in this research obviously leave room for future studies, especially in the direction of engaging other channels through which the main concerns of inclusive development and environmental sustainability underlying the SDG agenda can be achieved. Moreover, assessing how these findings are relevant to other developing countries is worthwhile.

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Appendix

Appendix 1: Segments of the financial system by degree of formality in Paper's context

<table>
<tr><th colspan="3">Paper's context</th><th>Tiers</th><th>Definitions</th><th>Institutions</th><th>Principal Clients</th></tr>
<tr><td>Formal financial system</td><td rowspan="3">IMF Definition of Financial System from International Financial Statistics (IFS)</td><td>Formal Financial sector (Deposit Banks)</td><td>Formal banks</td><td rowspan="2">Licensed by central bank</td><td>Commercial and development banks</td><td>Large businesses, Government</td></tr>
<tr><td rowspan="3">Semi-formal and informal financial systems</td><td rowspan="2">Semi-formal financial sector (Other Financial Institutions)</td><td>Specialized non-bank financial institutions</td><td>Rural banks, Post banks, Saving and Loan Companies, Deposit taking Micro Finance banks</td><td>Large rural enterprises, Salaried Workers, Small and medium enterprises</td></tr>
<tr><td>Other non-bank financial institutions</td><td>Legally registered but not licensed as financial institution by central bank and government</td><td>Credit Unions, Micro Finance NGOs</td><td>Microenterprises, Entrepreneurial poor</td></tr>
<tr><td>Missing component in IFS definition</td><td>Informal financial sector</td><td>Informal banks</td><td>Not legally registered at national level (though may be linked to a registered association)</td><td>Savings collectors, Savings and credit associations, Money lenders</td><td>Self-employed poor</td></tr>
</table>

Source: Asongu and Acha-Anyi (2017)

Appendix 2: Definitions of Variables

Variables	Signs	Definitions of variables (Measurements)	Sources
Income Inequality	Gini Coefficient	"*The Gini coefficient is a measurement of the income distribution of a country's residents*".	GCIP
CO2 emissions per capita	CO2	CO2 emissions (metric tons per capita)	WDI
Financial Access	Pcrdof	Private domestic credit from deposit banks and other financial institutions (% of GDP)	FDSD
Mobile Phones	Mobile	Mobile cellular subscriptions (per 100 people)	WDI
Political Stability	PolS		WGI
Trade Openness	Trade	Imports plus Exports of Goods and Services (% of GDP)	WDI
Urban Population	Upop	Urban Population (% of Total Population)	WDI
Remittances	Remit		
Middle Income	MI	"There are four main World Bank income groups: (i) high income, $12,276 or more; (ii) upper middle income,$3,976-$12,275; (iii) lower middle income, $1,006-$3,975 and (iv) low income, $1,005 or less".	WDI, Asongu, Nwachukwu and Pyke (2019)
Petroleum Exporting	Oil	"Stratification by natural resource-wealth is exclusively based on petroleum exports which represent at least 30 percent of the country's GDP for a minimum of one decade of the study period"	WDI, Asongu, Nwachukwu and Pyke (2019)

WDI: World Bank Development Indicators of the World Bank (https://databank.worldbank.org/source/world-development-indicators).

FDSD: Financial Development and Structure Database of the World Bank

(https://www.worldbank.org/en/publication/gfdr/data/financial-structure-database).

GCIP: Global Consumption and Income Project (http://gcip.info/).

WGI: World Governance Indicators of the World Bank (https://info.worldbank.org/governance/wgi/).

Appendix 3: Summary statistics (2004-2014)

	Mean	SD	Minimum	Maximum	Observations
Gini Coefficient	0.586	0.034	0.488	0.851	428
CO2 emissions per capita	0.934	1.823	0.020	9.979	429
Financial Access	21.055	25.319	0.873	150.209	414
Mobile Phones	47.148	37.672	1.272	171.375	425
Political Stability	-0.475	0.909	-2.687	1.182	429
Trade Openness	76.756	41.186	19.458	311.354	415
Urban Population	16.792	11.034	4.595	59.915	264
Remittances	4.549	7.048	0.00003	50.818	383
Middle Income Countries	0.410	0.492	0.000	1.000	429
Petroleum Exporting Countries	0.179	0.384	0.000	1.000	429

S.D: Standard Deviation. CO2: Carbon Dioxide.

Appendix 4: Correlation matrix (uniform sample size: 222)

	Gini	CO_2	Finance	Mobile	PolS	Trade	Upop	Remit	MI	Oil
Gini	1.000									
CO_2	0.736	1.000								
Finance	-0.115	-0.090	1.000							
Mobile	0.194	0.467	0.073	1.000						
PolS	0.240	0.206	0.149	0.031	1.000					
Trade	-0.051	-0.048	-0.070	-0.074	0.028	1.000				
Upop	0.281	0.426	-0.101	0.250	-0.053	0.531	1.000			
Remit	-0.069	-0.034	-0.077	0.035	-0.073	0.285	0.158	1.000		
MI	0.116	0.398	-0.073	0.352	-0.217	-0.177	0.319	-0.111	1.000	
Oil	-0.298	-0.024	-0.044	0.013	-0.440	-0.081	0.203	0.043	0.482	1.000

Gini: the Gini Coefficient. CO_2: Carbon dioxide emissions. Finance: Financial Access. Mobile: Mobile Phones Penetration. PolS: Political Stability. Trade: Trade Openness. Upop: Urban Population. Remit: Remittances. MI: Middle Income. Oil: Petroleum-Exporting Countries.