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WORKING PAPER SERIES

233, 2025

BUSINESS CONSTRAINTS, INFORMATION TECHNOLOGY AND INCOME INEQUALITY IN SUB-SAHARAN AFRICA

Forthcoming : Journal of Entrepreneurship

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Abstract

The objective of the study is to examine how information and communication technology can be used to moderate the unfavorable effects of doing business constraints on income inequality in 48 sub-Saharan African countries for the period 2004 to 2019. The Gini coefficient is used as the income inequality indicator whereas the ICT dynamics employed include: mobile phone penetration and internet subscriptions. Ten indicators of doing business constraints are also employed. From the findings, for the most part, doing business constraints increase income inequality while ICT moderates the positive effect of doing business constraints on income inequality. Thresholds of ICT at which the doing business constraints no longer increase income inequality are provided. At these established ICT penetration thresholds, ICT effectively moderates doing business constraints to reduce income inequality.

Keywords: Entrepreneurship, information technology, income inequality
JEL Classification: E60; F40; F59; D60; O55

1.Introduction

The present exposition aims to assess how information and communication technology (ICT) moderates the incidence of doing business constraints on income inequality in sub-Saharan African (SSA) nations. The inquiry is motivated by three main fundamentals in the extant scholarly and policy literature on the subject, especially as it pertains to *inter alia*: (i) the importance of ICT in reaching development outcomes in Africa, such as those directly associated with poverty and income inequality; (ii) the relevance of entrepreneurship and doing business dynamics in achieving similar outcomes of economic and inclusive development and (iii) attendant gaps in the extant policy and scholarly literature on the subject. What follows expands on the underlying motivational reasons in the same chronological order that they are highlighted.

First, there is some agreement that improving technology infrastructure can contribute to economic prosperity and, consequently, structural change, based on the body of research on the relationship between information technology, entrepreneurship and economic development (Ben Ali, 2020; Dossou et al., 2023a; Asongu & Bouanza, 2024; Régnier, 2023; Khadria & Mishra, 2023; Shi, 2023; Rao & Liefner, 2023; Fuamba et al., 2023). Additionally, press freedom promotes political democracy, which in turn boosts economic propriety (Audi, 1990). Thus, a free press monitors the government and protects the people from governmental corruption, according to Audi (1990). This viewpoint is supported by additional research (Dossou, 2023; Xu et al., 2021; Xu et al., 2022; Dossou et al., 2023a, 2023b), which also imply that decreasing corruption speeds-up economic development by lowering poverty, bridging income inequality gaps, and creating jobs. In addition, a free press prevents power abuse and guarantees public authorities' accountability. Ben Ali (2020), who shares this opinion, contends that when the press uses ICT to make it easier for the public to file grievances and disclose administrative abuses, then people are endowned with more power to hold the corresponding authorities accountable for their government actions. Voter knowledge asymmetry has decreased recently thanks to ICT-assisted election administration (Ben Ali, 2020). During political campaigns, the evaluation of incorrect information and erroneous remarks is made possible by the use of ICTs (Ben Ali, 2020). ICT exposed significant levels of corruption, which sparked a political revolution and the Arab Spring in North Africa (Dossou et al., 2023b; Ben Ali, 2020).

Second, the importance of entrepeneurship and the doing of business in reaching similar outcomes is articulated in Section 2.1.2, especially as it pertains to extant literarture on the subject. In what follows, the corresponding stylized facts that are relevant to the positioning of the problem statement are discussed. In accordance with the UNCTAD (2014), science, technology and innovation (STI) policies are considerable factors that contributed to socio-

economic change. Hence, according to the narrative, attendant STI measures are fundamental in contructing societies that are inclusive especially in the light of departing from traditional societies and building socio-economic structures that are more sustainable. It is also worthwhile to articulate that boosting development that is inclusive is also essential in consolidating competition within business structures. It follows that when STI policies are being formulated and implemented, these also double as alternative mechanisms for enhancing innovation that is inclusive. As an extension to the underlying policy literature, the study is positioned in terms of assessing the relevance of ICT in moderating the unfavorable incidence of doing business constraints on income inequality. The underlying positioning is also motivated by an apparent gaps in the extant scholarly literature on the subject.

Third, of the extant literature on the subject that is summarised in Section 2, the study in the body of existing literature that most closely resembles this one is Tchamyou et al. (2019); a study that has focused on nexuses between information technology, financial access and income inequality in Africa. Accordingly, the research has examined the relevance of ICT on income inequalty via financial development dynamics of depth (i.e., liquid liabilities and money supply); efficiency (i.e., within banking and finacial system perspectives); activiity (i.e., from banking and financial system standpoints) and financial activity. The study has focused on 48 African countries for the period 1996 to 2014 using the generalised methods of moments (GMM) estimation approach. According the findings, whereas financial size and depth mitigate income inequality, contingent on information technology, only the incidence of financial depth in mitigating income inequality withstands empirical srcutinty when time invariant ommitted variables are acknowleged as the variables that are strictly exogenous. The authors have furher extended the analysis by fractioning financial depth into financial sector components, notably: formal, informal, semi-formal and non-formal fiancial sectors of the economy. According to the extended results, information technology dampens income inequality by means of financial sector formalization and formal financial sector development. In summary, Tchamyou et al. (2019) have contributed simultaneously to the strand of macroeconomic literature on how financial development is measured as well as have responded to another evolving strand of literaure on how sustainable development goals (SDG) within the remit of reducing income inequality (i.e., SDG1) can be mitigated.

The rest of the paper is partitioned in the following manner. Theoretical underpinnings and the corresponding literature review motivating the positioning of the study are covered in Section 2 while the data and corresponding methodology are discussed in Section 3. The empirical results and attendant discussion are covered in Section 4. The study concludes in Section 5 with implications and future research directions.

2. Theoretical underpinnings and literature review

2.1 Literature review

2.1.1 ICT and income inequality

The nexus between ICT and income inequality is discussed in two main strands, especially as it pertains to the: (i) favorable empirical results or the negative linkage between ICT and income inequality and (ii) unfavorable results on the opposite linkage. The strands are expanded in the same chronology as highlighted.

In the first strand of favorable empirical findings, Yin and Choi (2023) use panel data from the Group of 20 countries for the years 2002–2018 to investigate the direct and moderating effects of digitalization on income inequality. They discover that although the effects vary by income level, digitalization reduces income inequality. Additionally, foreign direct investment contributes to closing the income gap across the board. The authors also show that middle-class nations are more affected by digitalization's ability to close the income gap than are high-income nations. Ndoya and Asongu (2024) examine how the digital divide has affected the disparity in income between 2004 and 2016 in sub-Saharan Africa. They discover that the influence of the digital gap on income inequality is distinct across two separate groups of nations, which differ based on the degree of globalization, using a finite mixture model on a sample of 35 sub-Saharan African nations. Furthermore, they demonstrate that the majority of globalized nations are more likely to fall into the category where the digital gap has a negative impact on income inequality.

Zhu et al. (2023) use a panel dataset that spans 100 nations from 2005 to 2019 to examine how the trade of digital services affects income inequality within countries. They consistently uncover evidence that the trade of digital services generally has a detrimental impact on income inequality. In high- and middle-income nations, this effect is demonstrated to be statistically significant, whereas in low-income countries, it is negligible. Ashenafi and Dong (2022) employ rounds of survey data from 2011, 2014, and 2017 from 39 African countries to assess the impact of Fintech and financial inclusion on income inequality empirically. They derive three main conclusions from their use of two-stage least squares estimation and pooled ordinary least squares. First, institutional issues such as political stability, government effectiveness, and the ability to fight corruption influence Fintech and financial inclusion. Second, by encouraging people to open legitimate bank accounts, fintech advances financial inclusion. Third, financial inclusion and fintech exacerbate economic inequality.

Hodula (2023) investigates whether shifts in income inequality can be linked to the expansion of fintech and big tech lending. The author concludes that there is a correlation between the decline in income inequality and the emergence of fintech and big tech lending, using a large

panel of 78 nations from 2013 to 2019. This somewhat disappointing outcome, meanwhile, is limited to nations having substantial current financial inclusion levels. Demir et al. (2022) investigate the connections between FinTech, financial inclusion, and income inequality for a panel of 140 countries using the Global Findex waves of survey data from 2011, 2014, and 2017. They find new evidence that financial inclusion is a crucial pathway through which FinTech lowers income inequality, based on quantile regression analysis. Additionally, they discover that whereas financial inclusion dramatically lowers inequality at every quantile of the inequality distribution, these benefits are mostly linked to wealthier nations. Nguyen (2023) empirically examines the effects of digitalization and foreign direct investment, as well as their interactions, on income inequality in rich and developing nations from 2002 to 2019, using the internet and fixed broadband subscribers as proxies for digitalization. By applying the system general method of moments estimators to 30 developed and 35 developing countries, the author finds that: digitalization reduces income inequality in both groups; foreign direct investment increases income inequality in developed countries but decreases it in developing countries; and the interaction term narrows income inequality in developed countries but widens it in developing countries.

Nguyen (2022) similarly investigates the impact of digitalization on inequality between 2002 and 2020 for a balanced panel dataset of emerging economies and a balanced panel dataset of advanced economies. Using the Pooled Mean Group estimators and the system-Generalized Method of Moments, the author shows that digitalization increases inequality in underdeveloped economies while decreasing it in developed ones. Li (2023) examines the effects of digital inequality on income distribution using data from the China Rural Revitalization Survey (CRRS). The results show that digital inequality significantly reduces household income, with low-income households being more negatively impacted. It is also apparent from the findings that income inequality within households is exacerbated by digital inequality, with the middle-class group suffering more severely from this phenomenon. Through an increase in employment in physical labor, broadband internet reduces income inequality, according to Houngbonon and Liang (2021) who use an instrumental variable estimate technique. These impacts are strong in places with a large service industry or high-speed internet connectivity, and such increase with the availability of skilled labor. Furthermore, compared to high-income areas, low-income communities benefit more from the spread of broadband internet.

With respect to the second strand of unfavorable and insignificant linkages, the attendant studies are sparse. It can be noted in this strands that Mohd et al. (2021) examine how digital technology has affected the correlation between financialization and income inequality in 54 nations between 2010 and 2015. The findings indicate that the disparity in income is widened by financialization and digital technologies. Consoli (2023) assesses the connections between wealth disparities and digital skills for an imbalanced panel of 103 European regions from 2003

to 2013. The findings indicate that there are significant differences in the link between digital skills and inequality across different income categories. Specifically, it is found that while digitalization tends to reduce inequality among higher income groups, it actually increases inequality among less affluent individuals.

2.1.2 Entrepreneurship and income inequality

The narrative on the nexus between entrepreneurship and income inequality can also be discussed in two main strands, especially as it relates to the favorable nexus between entrepreneurship and income inequality and the unfavorable or insignificant linkage between entrepreneurship and income inequality. The highlighted strands are also expanded in the same chronology as highlighted in what follows.

In the first strand on the favorable relationship between doing business in terms of entrepreneurship and income inequality, Roberto et al. (2022) investigate how unemployment and entrepreneurship affect income inequality in the Philippines. The results of their time-series multiple regression model, which employed the Ordinary Least Squares technique, show that entrepreneurship has a beneficial impact on income inequality, even while the unemployment rate had no discernible effect on the dependent variable. Ofori-Sasu and Abor (2023) investigate how FDI inflows and entrepreneurship together affect Africa's economic prosperity. They use the system generalized method of moments (GMM) dynamic technique on a panel dataset including 52 African economies from 2006 to 2020. According to their research, while entrepreneurship has a favorable long-term impact on economic wealth, it has a corresponding short-term negative impact. They draw the conclusion that entrepreneurship lowers economic wealth but enhances it when FDI inflows into a nation increase, based on the marginal impacts. Karabetyan (2023) looks into how the overall sustainable development of 15 high-income countries between 2002 and 2018 was impacted by entrepreneurial activity, as measured by the total amount of early-stage entrepreneurial activity and ICT development. Using a structural break in the Westerlund and Edgerton cointegration test, the author demonstrates that both entrepreneurial activity and ICT development have a long-term positive impact on sustainable development, but that ICT's impact on overall sustainable development is greater than that of entrepreneurial activity.

Yerrabati (2022) investigates how business might help reduce poverty. A five-year mean encompassing 56 developing nations between 1995 and 2019 is employed. The dynamic two-step system GMM technique serves as the foundation for the empirical study. The findings indicate that, albeit to a lesser extent, self-employment lowers poverty in developing nations. However, depending on the definition and threshold of poverty, self-employment had different benefits in reducing it. The association between entrepreneurship and income inequality is

estimated by Atems and Shandy (2018). Employing the system GMM estimator and US state-level data spanning 1989 to 2013, they ascertain a statistically significant positive correlation between income disparity and entrepreneurship. The usefulness of entrepreneurship in mitigating economic disparity in developing nations is examined by Mohamad (2021). For the years 2009 through 2017, a sample of 47 developing nations was used in the corresponding study. Employing the GMM, the study's main conclusions show that, in emerging nations, a higher degree of entrepreneurship is associated with lower levels of income inequality. Shahabadi et al. (2023) look into how, between 2009 and 2019, entrepreneurship affected income disparity in a few industrialized and developing nations. The results, which were obtained by applying the GMM, demonstrate that necessity-oriented entrepreneurship significantly and negatively affects income disparity in both groups within the chosen countries. Nonetheless, developing nations have a greater estimated coefficient. Additionally, in both groups of the chosen nations, opportunistic entrepreneurship has a favorable and large impact on income disparity. Developed nations, however, have a higher estimated coefficient.

In the second strand on an unfavorable linkage between entrepreneurship and income quality or linkages that have been established to be insignificant, Sharma and Gupta (2021) use the Autoregressive Distributed Lag (ARDL) Bounds Testing Approach of Cointegration and Error Correction Model (ECM) to reexamine the relationship between entrepreneurship and income disparities in India for the years 1981–2017. The registered manufacturing sector serves as the study's base, while the gross capital creation and profits made are employed as indicators of entrepreneurship and the Gini coefficient as a stand-in for income inequality. They discover that whereas capital production has a short-term beneficial influence on the Gini coefficient, it has a long-term negative impact. The study comes to the conclusion that there is a reciprocal relationship between income inequality and entrepreneurship in India. Similarly, a study conducted by Liu and Qian (2023) investigates the impact of self-employment versus new firm formation on income disparity in US cities. A regression analysis using metropolitan areas from 2005 to 2015 demonstrates that a rise in the number of new firms formed reduces the inequality of household income. On the other hand, inequality rises with increased self-employment. Additionally, Schneck (2018) uses representative German data and unconditional quantile regression analysis to show how an increase in the proportion of self-employed individuals in the labor force causes income inequality at the bottom and creating higher earning potentials at the very top of the hourly income distribution.

2.2 Theoretical underpinnings and hypotheses development

Three main facets of the study are presented in this section: (i) the theoretical background on the interaction between ICT, doing business constraints and inclusive development; (ii) setting the theoretical foundations in context within the study's purview and (iii) development of the

testable hypotheses from the theoretical bases and the contextual features as mentioned in earlier sections. We address each of these points subsequently in the following paragraphs.

First, Asongu and Bouanza (2024) present the theoretical stance in the first strand. The study's position is based on two main hypotheses, specifically on how ICT supports the connection between structural transformation (i.e., by means of doing business as understood in this study) and development outcomes. According to Amavilah et al. (2017) and Hasan & Bousrih (2020), the theories are Schumpeter's inventive growth theory and the endogenous growth theory.

Taking the aforementioned into consideration, Schumpeter's creative growth theory is the first theory the study looks at. An economic sphere comprises fundamental information technology drivers that promote the doing of business. Theoretical research suggests that information technology and the aforementioned doing business dynamic processes interact to cause economic changes (Asongu & Bouanza, 2024) which engender inclusive development outcomes such as income inequality. According to Amavilah et al. (2017) and Hasan and Bousrih (2020), interactions between information technology and entrepreneurial innovation within the remit of doing business serve as a catalyst for structural transformation in an economy with obvious consequences on income distribution.

The notion of endogenous growth is the second theory examined by the study. According to the corresponding theory, a nation's macro- and microeconomic forces interact to cause economic development which is associated with income distribution. Following this theory, information technology and doing business dynamics—the choice variables, determinants, and indicators used in this study—are essentially domestic in character, suggesting that domestic policies influence how they interact. Stated differently, information technology can ascertain the ways in which the doing of business and entrepreneurship influence income distribution (Amavilah et al., 2017; Hasan & Bousrih, 2020; Asongu & Bouanza, 2024).

In the second strand, how the underlying theoretical foundations might be applied contextually to the current study is discussed, with particular attention to how the channel, moderating, and outcome variables are selected. In relation to income inequality, the current study attempts to evaluate the moderating impact of information technology on the doing of business and how such interactions ultimately influence income distribution. The rationale behind selecting information technology dynamics as the primary moderating variables, is rooted in the previously discussed ideas of endogenous growth theory and Schumpeter's innovation theory. There is a supposition that information technology moderates doing business constraints to produce favorable effects on income distribution, not least, because ICT has

been documented to improve conditions for doing business as well as avail opportunities for the reduction of income inequality and poverty (Asongu & Bouanza, 2024; Saba et al., 2024).

Third, building on the discussed theoretical underpinnings as well as their contextualization within the remit of the present study, the following hypotheses can be objectively formulated in the light of the motivation of study:

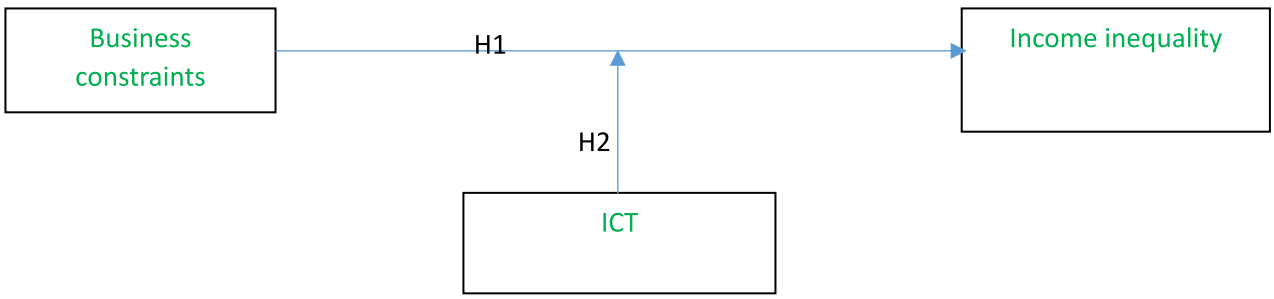
Hypothesis 1: Doing business constraints increase income inequality

Hypothesis 2: ICT dampens the positive effect of doing business constraints on income inequality.

Beyond, the empirical literature that has been used to substantiate the testable hypotheses, the corresponding hypotheses are also supported by the policy literature, especially as it pertains to the relevance of ICT in empowering people to reduce income inequality and poverty (Maidment, 2018), especially by means of reducing constraints in the doing of business, as considered within the remit of the study.

Whether, the testable hypotheses washstand empirical scrutiny is a question of empirical validity that is covered in the section that follows. It is relevant to note that, the doing business or entrepreneurship indicators as conceived within the remit of the present exposition can be understood as doing business constraints, not least, because the corresponding dynamics reflect conditions for doing business for which, when increased, actually hamper a doing business environment. For instance, the time that is required to start a business actually represents a doing business constraint if it increases. This the case with all the engaged ten doing business indicators employed in the empirical section of the study. It is thus relevant to note that since, the considered doing business indicators are conceived and defined in terms of cost and time, it follows that an increment of the corresponding doing business indicators is indicative of additional doing business constraint.

Figure 1: The moderating effect of ICT on the relationship between business constraints and income inequality



To improve readability and flow, the conceptual framework supporting the tested hypotheses is presented in Figure 1. Therefore, before stating the testable hypotheses, the relevance of the transmission channel and moderating variable have been discussed, given that the study contains interactive regressions. Thus, Hypothesis 1 describes the primary channel, which is business constraint, whereas Hypothesis 2 describes how ICT mitigates the impact of business constraints on income inequality. The next section will address the empirical validity, which is the question of whether the testable hypotheses withstand empirical investigation.

3. Data and methodology

3.1 Data

The present study focuses on data from 48 sub-Saharan African countries for the period 2004-2019. The periodicity and sample are constrained by data availability at the time of the study. In order to understand how the variables are defined, it is relevant to recall that the present study is positioned on assessing the how ICT moderates the incidence of doing business constraints on income inequality. The corresponding data are obtained from two main sources, namely: World Development Indicators (WDI) of the World Bank and the World Income Inequality Database (WIID). The main outcome variable which is income inequality is obtained from the WIID while the independent variables of interest, the moderating and control variables are sourced from WDI of the World Bank. The choice of the Gini coefficient as the measurement for income inequality is consistent with contemporary literature on income distribution (Tchamyou, 2019).

Two main ICT moderators are employed, namely: mobile phone penetration and internet penetration, in accordance with contemporary ICT literature (Tchamyou et al., 2019; Saba et al., 2024). Accordingly, fixed telephone lines are not considered because these are not increasingly used in the African continent (Saba et al., 2024). It is relevant to highlight that the choice of the moderating variable is for the most part motivated by the potential for higher penetration, in line with contemporary policy threshold literature (Asongu & Odhiambo, 2021). Accordingly, given that mobile phone penetration and internet penetration have a higher penetration potential compared to fixed telephone lines which are no longer used for the most part, the study does not consider fixed telephone lines as a relevant moderator, not least, because, fixed telephone lines reflect a very low penetration potential in the continent. Moreover, it is not very likely for policy makers to device policies destined to increase fixed telephone lines, compared to similar policies that are destined to promote internet penetration and mobile phone penetration in the continent (Asongu & Odhiambo, 2022).

Consistent with the motivation of the study as well as contemporary doing business literature, ten doing business indicators are employed (Asongu, 2023). These doing business constraint indicators are: cost of business start-up procedures (% of GNI per capita); procedures to register property (measured in number); start-up procedures to register a business (proxied by number); time required to build a warehouse (appreciated in days); time required to enforce a contract (measured in days); time required to register property (proxied by days); time required to start a business (appreciated in terms of days); time to export or border compliance (in terms of hours); time to prepare and pay taxes (measured in hours) and time to resolve insolvency (proxied by years). It is important to note that, in line with the extant literature on the subject, the used of multiple doing business indicators is to provide room for more policy implications

(Asongu et al., 2019).

In order to account for variable omission bias and thus, ensure that the estimations are robust to attendant macroeconomic determinants of income inequality, three main control variables are involved in the conditioning information set, namely: secondary education within the remit of gender parity, real output in terms of logarithm of GDP per capita and political stability. These indicators have been documented in the extant literature as determinants of income inequality (Tchamyou, 2019; Ponce et al., 2023; Chancel et al., 2023; Özdemir, 2023). In accordance with the attendant literature, the study anticipates that each of these elements in the conditioning information should negative affect income equality. In what follows that expected signs are discussed in more perspective.

First, secondary gender parity education is expected to reduce income inequality because by construction and definition, it is an indicator of gender inclusion. It follows that, this indicator is expected to reduce income inequality or improve the distribution of income, unless policy toward gender parity education is tailored to favor wealthier factions of the population in society. Moreover, given that the study is focused on interactive regressions, the expected signs may not also hold, especially in scenarios where the gender inclusive control variable is correlated with the interactive terms. Second, GDP per capita is expected to reduce income inequality contingent on an equitable distribution of the fruits of economic prosperity. Accordingly, in events where economic growth is not evenly distributed across the population, growth in GDP per capita is not necessarily associated with reductions in income inequality and vice versa. Third, political stability intuitively provides enabling conditions for economic prosperity and by extension, the equitable distribution of the underlying fruits of economic prosperity across the population.

The list of sampled countries is provided in Appendix 1, whereas Appendix 2 provides the definitions of the variables as well as their corresponding sources. The summary statistics is disclosed in Appendix 3 whereas the correlation matrix is provided in Appendix 4. It is relevant to note that since the study is dealing with interactive regressions, the summary statistics is relevant for the computation of net effects and/or corresponding thresholds, not least, because as documented in Brambor et al. (2006), in order to limit the shortcomings of interactive regressions, such net effects and/or thresholds should be computed. The net effects and thresholds combine both the conditional or interactive impacts and the unconditional effects, in order to avoid the concern of multicollinearity that is overlooked in interactive regressions (Tchamyou, 2019; Asongu & Odhiambo, 2021).

3.2 Methodology

3.2.1 Specification

Contingent on the elements of motivation governing the adoption of dynamic models in the empirical research (Efobi *et al*., 2019; Tchamyou, 2019; Manasseh *et al*., 2022), the present study adopts the generalized method of moments (GMM). Consistent with attendant studies motivated prior, the first motivational element is that the data structure should be consistent with empirical strategy to be adopted. Accordingly, such is the case because employing the GMM supposes that the number countries or groups should be correspondingly higher than the attendant number of years in each country or group. It follows, thus that a fundamental premise for the employment of the GMM is the fulfilment of the corresponding requirement: N>T, with N being the number of countries and T, the corresponding years in each country. Second, still related to the attendant literature, another condition for the employment of the adopted empirical strategy is that the outcome variable should exhibit some form of persistence, especially as it relates to non-contemporary elements of the outcome variable influencing the contemporary values of the corresponding outcome variable. Such is the notion of persistence, which is also understood in terms of stochasticity. Accordingly, persistence is apparent in the outcome variable, not least, because the criterion of persistence in the outcome variable is fulfilled. Accordingly, the coefficient of correlation between level series of the outcome variable and their corresponding first lag series is higher than the rule of thumb of 0.800, documented in the extant GMM-centric literature (Tchamyou, 2019).

Third, it is also imperative to take into account the perspective that, country-country differences or heterogeneities are considered in the GMM approach, not least, because the estimation process involves the use of panel data. Fourth, cross-sectional dependence is also considered in the study, especially as it pertains to specification being tailored to account for tim-invariant omitted variables in terms of years. Accordingly, by controlling for years, it is apparent that factors that are not specific to countries are taken into account. It is worthwhile to note that the control for cross-sectional dependence by means of time-invariant omitted variable is also designed to account for the unobserved heterogeneity which is obviously one of the four main causes of endogeneity (Tchamyou et al., 2019). Fifth, the empirical strategy is also tailored to account for the simultaneity or reverse causality dimension of endogeneity. Such is implemented by controlling internal instruments as opposed to external instruments, owing to the difficulty of finding appropriate external instruments. Such justification has been provided in the extant literature to motivate the employment of the GMM empirical strategy (Tchamyou, 2009; Tchamyou et al., 2019).

Equation (1) and Equation (2) highlight, the level and first difference equations that are relevant in the estimation of a system GMM:

$$IN_{it} = \emptyset_0 + \emptyset_1 IN_{it-\tau} + \emptyset_2 ICT_{it} + \emptyset_3 EN_{it} + \emptyset_4 Inter_{it} + \sum_{k=1}^{3} \delta_k W_{hit-\tau} + \varphi_i + \omega_t + \varepsilon_{it} \quad (1)$$

$$IN_{it} - IN_{it-\tau} = \emptyset_1 (IN_{it-\tau} - IN_{it-2\tau}) + \emptyset_2 (ICT_{it} - ICT_{it-\tau}) + \emptyset_3 (EN_{it} - EN_{it-\tau}) + \emptyset_4 (Inter_{it} - Inter_{it-\tau}) + \sum_{k=1}^{3} \delta_k (W_{hit-\tau} - W_{hit-2\tau}) + (\omega_t - \omega_{t-\tau}) + (\varepsilon_{it} - \varepsilon_{it-\tau}) \quad (2)$$

where IN shows income inequality; $\emptyset_0$ represents the constant; ICT denotes information and communication technology understood within premises of mobile money subscriptions and internet penetration; EN stands for ten entrepreneurship dynamics discussed in the data section; *Inter* reflects the interaction between an entrepreneurship dynamic and ICT; W represents the vector of variables used in the conditioning information set (i.e., gender parity secondary education, real output and political stability); τ reflects tau or the coefficient of autoregression which in accordance with the extant GMM-centric literature (Boateng et al., 2018), should be unity or one because one year is enough to capture past information in an estimation exercise; ω_t reflects the time-specific constant of the study; φ_i shows the country-specific effect and ε_{it} represent the error term.

In accordance with the extant authoritative literature on the subject (Roodman, 2009), the adopted analytical procedure is tailored such that the adopted GMM technique is based on forward orthogonal deviations. It is worthwhile to articulate that the forward procedure is an extension of the difference GMM estimation approach (i.e., of Arellano & Bover, 1995) which has also been documented to be less robust, especially as it pertains to accounting for cross-sectional dependence and avoiding the proliferation of instruments because a collapse option is used in the estimation exercise to mitigate the underlying proliferation of instruments that are likely to bias estimated coefficients and by extension, render the estimated models invalid. The advantages of the GMM technique based on forward orthogonal deviations as opposed to more non-contemporary approach is growingly being used in the extant literature focusing assessing nexuses between macroeconomic dynamics by means of the GMM estimation strategy (Boateng *et al*., 2018; Tchamyou *et al*., 2019; Efobi *et al*., 2019). It is also worthwhile to note that the involvement of time-invariant omitted variables that are designed to account for cross-sectional dependence is worthwhile and in accordance with the extant literature on the subject, not least, because considering time-invariant factors or common features across countries can substantially bias the considered corresponding coefficients (Xu et al.,2022; Dossou et al., 2023a, 2023b; Xuanming et al., 2023).

3.2.2 Identification, simultaneity and exclusion restrictions

In order to avoid the adopted GMM technique being considered a black box, there are some underlying elements in the specification that have to be clearly articulated, especially as it pertains to clarifying notions of identification, simultaneity and exclusion restrictions as considered within the remit of the present exposition. These elements are expanded in what following using the same chronology as highlighted.

First, in terms of identification, the process of identification in the GMM-centric literature consists of clearly defining, the outcome variables, the endogenous explaining variables and the corresponding strictly exogenous variables. As it stands, in accordance with the extant GMM-centric literature (Tchamyou et al., 2019): (i) the outcome variable employed in the study is income inequality, understood in terms of the Gini coefficient. (ii) Still in line with the corresponding literature, the endogenous explaining variables which are variables with both endogenous and exogenous sides, are considered to be the independent variables of interest of the study (i.e., ICT and doing business constraint dynamics). It follows that in the GMM specification, these variables are positioned in the *gmmstyle* side of the Roodman (2009) GMM specification. Moreover, the control variables are also involved in the corresponding GMM style, because such are also considered not to exhibit strict exogeneity. (iii) The adopted strictly exogenous variable is consistent with both Roodman (2009) and the extant more contemporary empirical literature on the subject (Tchamyou & Asongu, 2017). The strand of studies is consistent with the position that it is more worthwhile to adopt the time factor or years as the strictly exogenous because it is unlikely for the time factors to be endogenous after a first difference.

Second, consistent with elements of the introduction of this section, the narrative on simultaneity consists of articulating how concerns surrounding reverse causality can be addressed within the context of the empirical analysis. Hence, building on the extant literature which has been highlighted in the preceding paragraph, transformations of Helmert nature are considered in the process of addressing the corresponding concerns pertaining to simultaneity or reverse causality. It is thus, important to articulate the transformation of Helmert nature to address the reverse causality concern by excluding fixed impacts which can potentially bias estimated coefficients, especially when the lagged dependent variable is highly correlated with corresponding fixed effects. The underlying procedure for the elimination of the concern of simultaneity is consistent with the extant GMM-centric contemporary and non-contemporary literature, *inter alia*, Arellano and Bover (1995), Love and Zicchino (2006), Meniago and Asongu (2018) and Roodman (2009).

Third, in order for strict exogeneity to be exhibited by the adopted strictly exogenous variables, there is an underlying assumption that the considered strictly exogenous variable influence the

outcome variable, exclusively through the exogenous components of the retained endogenous explaining variables. In order to assess if the underlying strict exogeneity is apparent or not, the Difference in Hansen (DHT) test of the exogeneity of instruments is employed. It follows that in accordance with the extant studies (Amavilah *et al.*, 2017; Tchamyou *et al.*, 2018) for the hypothesis of strict exogeneity to be confirmed, the null hypothesis of the DHT should not be rejected.

4. Empirical results

The empirical results are disclosed in this section in four main tables. Table 1 focuses on nexus between income inequality, ICT (i.e., mobile phone penetration and internet penetration) and the first-three doing business constraint indicators (i.e., cost of business start-up procedure, procedure to register a property and start-up procedure to register a business) while Table 2 is concerned with linkages between income inequality, ICT and three other doing business constraint indicators (i.e., time required to build a warehouse, time required to enforce a contract, time required to register a property). Table 3 is concerned with the nexus between income inequality, three more doing business constraint indicators (i.e., time required to start a business, time to export (i.e. border compliance), time to prepare to pay taxes) and information technology while Table 4 focuses on connections between ICT, the time resolve an insolvency and income inequality. For each doing business constraint indicator, two specifications are considered, especially as it pertains to involving mobile phone penetration and internet subscriptions, respectively. It follows that the first-three tables have six specifications, respectively, while the last table (i.e., Table 4) has two specifications, accordingly.

In order to examine the relevance of the tested hypotheses, two conditions should be met. On the one hand, the estimated models should be valid. In accordance with mainstream studies on the subject, four information criteria are mobilized in order to assess the validity of the estimated models (Asongu & De Moor, 2017)[1]. Moreover, beyond the information criteria for the validity of models, for the testable hypotheses to be valid: (i) doing business constraints must positively affect income inequality (i.e., validity of *Hypothesis* 1) and (ii) ICT should interact with doing business constraints to reduce the positive effect of doing business constraints on income inequality, to the extent that, beyond some thresholds of ICT penetration, doing business constraints no longer have a positive effect of income inequality.

Consistent with the relevant thresholds literature (Ofori & Asongu, 2024), in order for the corresponding ICT policy thresholds to be policy-relevant and make economic senses, these should be within statistical range. In other words, in order for the computed thresholds to be policy-worthwhile, they should be situated between the minimum and the maximum of the moderating ICT variables apparent in the summary statistics. For instance, in the fourth column or third specification of Table 1, the mobile penetration threshold at which the procedure to register a property no longer increases income inequality is 98.00 (0.196/0.002) per 100 people.

[1] "*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 Fischer test for the joint validity of estimated coefficients is also provided*" (Asongu & De Moor, 2017, p.200).

It follows that 98 in every 100 people of the population should own a mobile phone in order for the considered doing business constraint to no longer increase income inequality in the sampled countries.

To put the above computation in more perspective, at the attendant threshold (i.e., 98.00%), the net effect on income inequality is zero or 0.000 = ([-0.002× 98.000] + [0.196]). Hence, when the mobile penetration level exceeds the established thresholds, the procedure to register a property no longer positively affect income inequality. In the computation of the net effect, 98.000 is the established threshold, 0.196 is the unconditional effect of the procedure to register a business while -0.002 is the corresponding conditional or interactive effect. Moreover, the computed mobile phone penetration makes economic sense and has policy relevance because it is within the statistical range of the mobile phone penetration apparent in the summary statistics. Furthermore, it is worthwhile to highlight that consistent with extant interactive regressions literature (Nchofoung et al., 2021, 2022), such computation of thresholds is necessary in order avoid the pitfalls of interactive regressions documented in Brambor et al. (2006) which partly consists of interpreting the estimated coefficients as in linear additive models.

In the light of above information criteria for the validity of estimated models and testable hypotheses, the following findings can be established from Tables 1-4. First, from Table 1: (i) mobile phone penetration and internet penetration moderate the positive incidence of the procedure to register a property for an overall negative effect on income inequality with corresponding thresholds of 98.00 (per 100 people) and 59.800 (% of the population), respectively. (ii) Mobile phone penetration effectively moderates the positive effect of start-up procedure to register a business on inequality with a corresponding negative threshold of 37.500 (per 100 people). Second, from Table 2 both mobile phone penetration and internet subscriptions moderate the positive effects of the time required to enforce a contract and time required to register a property. The corresponding thresholds are: (i) 77.333 mobile phone penetration (per 100 people) for the nexus between the time required to enforce a contract and income inequality; (ii) 29.833 internet subscription (% of the population) for the linkage between the time required to enforce a contract and income inequality; (iii) 12.187 mobile phone penetration (per 100 people) for the nexus between the time required to register a property and income inequality and (iv) 4.875 internet penetration (% of the population) for the linkage between the time required to register a property and income inequality. Third, no significant linkages from which to draw policy implications are apparent in Tables 3-4. Accordingly, for Tables 1-4: (i) "na" or "not applicable" is assigned when at least one estimated coefficient is not significant for the computation of thresholds while (ii) "nsa" or "not specifically applicable" is used when corresponding signs are unexpected and hence, relevant ICT

thresholds cannot be computed. Fourth, the significant control variables are broadly consistent with the narrative in the data section.

Table 1. Entrepreneurship, ICT and Inequality (First set of specifications)

	Dependent variable: Income Inequality (GINI)					
	COSTOSTART		PROREGPROP		STARTUPPROCED	
	MOBILE	INTERNET	MOBILE	INTERNET	MOBILE	INTERNET
L.GINI	**1.123*** **	**1.139*** **	**1.186*** **	**1.122*** **	**1.174*** **	**1.148*** **
	(0.019)	**(0.020)**	**(0.022)**	**(0.019)**	**(0.025)**	**(0.015)**
COSTOSTART (COST)	-0.000	**-0.001***				
	(0.000)	**(0.000)**				
MOBILE (MOB)	0.003		0.009		**0.017** **	
	(0.003)		(0.007)		**(0.007)**	
COST x MOB	**-0.00002** **					
	(0.000)					
INTERNET (INT)		**0.016** **		0.016		**0.049*** **
		(0.007)		(0.015)		**(0.015)**
COST x INT		**0.00009** **				
		(0.000)				
PROREGPROP (PROR)			**0.196***	**0.299*** **		
			(0.098)	**(0.085)**		
PROR x MOB			**-0.002***			
			(0.001)			
PROR x INT				**-0.005** **		
				(0.002)		
STARTUPPROCED (STAR)					**0.150** **	0.052
					(0.069)	(0.042)
STAR x MOB					**-0.004*** **	
					(0.001)	
STAR x INT						**-0.006*** **
						(0.002)
SSEG	**1.215** **	0.779	**1.271***	**3.004*** **	1.138	**3.148*** **
	(0.603)	(0.618)	**(0.756)**	**(0.955)**	(1.092)	**(1.062)**
LGDPPCAP	-0.349	**-0.490***	0.023	-0.256	0.362	**-0.704** **
	(0.222)	**(0.277)**	(0.236)	(0.303)	(0.262)	**(0.264)**
POLS	-0.275	-0.044	-0.146	-0.046	**-0.308** **	0.014
	(0.170)	(0.146)	(0.152)	(0.154)	**(0.131)**	(0.181)
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	**-5.799*** **	**-5.210** **	**-12.497*** **	**-9.302*** **	**-13.851*** **	**-6.434*** **
	(1.518)	**(2.232)**	**(2.440)**	**(2.291)**	**(1.473)**	**(2.127)**
ICT Thresholds	na	na	98.000	59.800	37.500	na
AR(1)	(0.312)	(0.299)	(0.303)	(0.289)	(0.324)	(0.304)
AR(2)	**(0.160)**	**(0.149)**	**(0.141)**	**(0.140)**	**(0.160)**	**(0.158)**
Sargan OIR	(0.000)	(0.000)	(0.000)	(0.002)	(0.019)	(0.014)
Hansen OIR	**(0.369)**	**(0.131)**	**(0.538)**	**(0.178)**	**(0.592)**	**(0.152)**
DHT for instruments						
a)Instruments in levels						
Hansen excluding group	**(0.778)**	**(0.881)**	**(0.863)**	**(0.866)**	**(0.944)**	**(0.764)**

Dif(null, H=exogenous)	**(0.191)**	(0.035)	**(0.294)**	(0.056)	**(0.291)**	(0.057)
b)IV(years, eq(diff))						
Hansen excluding group	(0.034)	**(0.370)**	**(0.243)**	**(0.140)**	**(0.308)**	**(0.654)**
Dif(null, H=exogenous)	**(0.869)**	**(0.113)**	**(0.681)**	**(0.302)**	**(0.687)**	(0.079)
Fisher	**349448.97*** **	**1,350,000*** **	**175496.67*** **	**1,860,000*** **	**128234.84*** **	**299432.61*** **
Instruments	41	41	41	41	41	41
Countries	45	45	45	45	45	45
Observations	421	406	412	398	412	398

Standard errors are in parenthesis. ***, ** , *: significance levels of 1%, 5%, and 10%, in that order. DHT: Variation in the Hansen Test for Instrument Subset Exogeneity. Dif: Variation. Over-identification Restrictions Test: OIR. Bold values are important in two ways. (1) Fisher statistics and calculated coefficients' importance. (2) The inability to reject the null hypotheses regarding the validity of the instruments in the Sargan and Hansen OIR tests and the absence of autocorrelation in the AR(1) and AR(2) tests. The mean value of mobile (55.024) and internet (11.802). na: not applicable because at least one estimated coefficient needed for the computation of net effects is not significant. The range of mobile penetration 0.207 to 185.559 is while the range of internet penetration is 0.031 to 74.756.

Table 2. Entrepreneurship, ICT and Inequality (Second set of specifications)

	Dependent variable: Income Inequality (GINI)					
	TIMEWAREHOUSE (TIMEWAR)		TIMENFORCONTR (TIMENFO)		TIMEREGPROP (TIMEREG)	
	MOBILE	INTERNET	MOBILE	INTERNET	MOBILE	INTERNET
L.GINI	**1.108*** **	**1.148*** **	**1.165*** **	**1.126*** **	**1.103*** **	**1.151*** **
	(0.018)	**(0.018)**	**(0.019)**	**(0.021)**	**(0.018)**	**(0.026)**
TIMEWAREHOUSE	**-0.002***	0.001				
	(0.001)	(0.001)				
MOBILE (MOB)	**-0.018*** **		**0.024*** **		**-0.007***	
	(0.004)		**(0.007)**		**(0.004)**	
TIMEWAR x MOB	**0.00006*** **					
	(0.000)					
INTERNET (INT)		**0.019***		**0.061*** **		-0.001
		(0.011)		**(0.014)**		(0.011)
TIMEWAR x INT		**-0.00014** **				
		(0.000)				
TIMENFORCONTR			**0.00232*** **	**0.00179** **		
			(0.001)	**(0.001)**		
TIMENFO x MOB			**-0.00003*** **			
			(0.000)			
TIMENFO x INT				**-0.00006*** **		
				(0.000)		
TIMEREGPROP					0.000195	0.000629
					(0.001)	(0.001)
TIMEREG x MOB					0.000016	
					(0.000)	
TIMEREG x INT						-0.000129
						(0.000)
SSEG	1.240	**4.277*** **	-0.461	**1.982** **	**3.687*** **	**2.036***
	(0.862)	**(1.300)**	(1.113)	**(0.977)**	**(1.085)**	**(1.191)**

LGDPPCAP	0.146	**-0.638****	**-0.620*****	**-1.023*****	-0.125	-0.309
	(0.196)	**(0.274)**	**(0.179)**	**(0.200)**	(0.209)	(0.250)
POLS	**-0.466*****	-0.097	0.101	**0.229****	**-0.586*****	-0.213
	(0.143)	(0.138)	(0.110)	**(0.094)**	**(0.141)**	(0.203)
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	**-7.506*****	**-7.894*****	**-6.147*****	**-2.864****	**-8.168*****	**-8.179*****
	(1.823)	**(2.202)**	**(1.354)**	**(1.101)**	**(1.556)**	**(1.957)**
ICT Thresholds	nsa	na	77.333	29.833	12.187	4.875
AR(1)	(0.284)	(0.294)	(0.310)	(0.299)	(0.307)	(0.283)
AR(2)	**(0.148)**	**(0.152)**	**(0.156)**	**(0.140)**	**(0.147)**	**(0.151)**
Sargan OIR	(0.000)	(0.001)	(0.000)	(0.013)	(0.000)	(0.005)
Hansen OIR	**(0.326)**	**(0.355)**	**(0.365)**	**(0.257)**	**(0.331)**	**(0.161)**
DHT for instruments						
a)Instruments in levels						
Hansen excluding group	**(0.994)**	**(0.974)**	**(0.807)**	**(0.706)**	**(0.384)**	**(0.877)**
Dif(null, H=exogenous)	**(0.084)**	**(0.111)**	**(0.178)**	(0.130)	**(0.324)**	(0.047)
b)IV(years, eq(diff))						
Hansen excluding group	(0.213)	(0.044)	**(0.705)**	**(0.260)**	**(0.331)**	**(0.484)**
Dif(null, H=exogenous)	**(0.442)**	**(0.812)**	**(0.229)**	**(0.310)**	**(0.354)**	**(0.114)**
Fisher	**341695.28*****	**340321.61*****	**315299.73*****	**163800.73*****	**215116.22*****	**938983.80*****
Instruments	41	41	41	41	41	41
Countries	44	44	45	45	45	45
Observations	405	393	412	398	412	398

Standard errors are in parenthesis. ***, ** , *: significance levels of 1%, 5%, and 10%, in that order. DHT: Variation in the Hansen Test for Instrument Subset Exogeneity. Dif: Variation. Over-identification Restrictions Test: OIR. Bold values are important in two ways. (1) Fisher statistics and calculated coefficients' importance. (2) The inability to reject the null hypotheses regarding the validity of the instruments in the Sargan and Hansen OIR tests and the absence of autocorrelation in the AR(1) and AR(2) tests. The mean value of mobile (55.024) and internet (11.802). na: not applicable because at least one estimated coefficient needed for the computation of net effects is not significant. nsa: not specifically applicable because an unexpected signs is apparent. The range of mobile penetration 0.207 to 185. 559 is while the range of internet penetration is 0.031 to 74.756.

Table 3. Entrepreneurship, ICT and Inequality (Third set of specifications)

	Dependent variable: Income Inequality (GINI)					
	TIMESTARTBUS (TIMESTAR)		TIMEXPORT (TIMEXP)		TIMETAXES (TIMETAX)	
	MOBILE	INTERNET	MOBILE	INTERNET	MOBILE	INTERNET
L.GINI	**1.139*****	**1.134*****	**1.094*****	**1.119*****	**1.191*****	**1.176*****
	(0.017)	**(0.020)**	**(0.029)**	**(0.011)**	**(0.029)**	**(0.034)**
TIMESTARTBUS	**0.0047****	0.004				
	(0.002)	(0.003)				
MOBILE (MOB)	-0.002		-0.014		-0.003	
	(0.004)		(0.009)		(0.004)	
TIMESTAR x MOB	**-0.0004*****					

	(0.000)					
INTERNET (INT)		0.012		0.009		0.022
		(0.008)		(0.010)		(0.014)
TIMESTAR x INT		**-0.001*** **				
		(0.000)				
TIMEXPORT			-0.005	-0.001		
			(0.005)	(0.001)		
TIMEXP x MOB			0.0001			
			(0.000)			
TIMEXP x INT				**0.0001** **		
				(0.000)		
TIMETAXES					0.001	**0.001***
					(0.001)	**(0.001)**
TIMETAX x MOB					-0.000	
					(0.000)	
TIMETAX x INT						-0.000
						(0.000)
SSEG	**2.175***	**1.811***	**-2.945*** **	-0.678	1.507	**2.223***
	(1.142)	**(0.930)**	**(1.012)**	(0.677)	(1.136)	**(1.321)**
LGDPPCAP	**0.455** **	0.043	**-0.686*** **	**-0.915*** **	-0.164	**-0.633** **
	(0.210)	(0.185)	**(0.227)**	**(0.321)**	(0.224)	**(0.303)**
POLS	**-0.410*** **	-0.090	**0.934*** **	**0.367***	**-0.378** **	0.017
	(0.139)	(0.200)	**(0.245)**	**(0.189)**	**(0.159)**	(0.146)
ICT Thresholds						
Constant	**-12.506*** **	**-9.396*** **	**3.501***	0.306	**-11.083*** **	**-7.849*** **
	(1.710)	**(1.690)**	**(2.047)**	(2.578)	**(2.050)**	**(2.601)**
Thresholds	11.750	---	---	---	---	---
AR(1)	(0.302)	(0.283)	(0.291)	(0.317)	(0.307)	(0.292)
AR(2)	**(0.147)**	**(0.154)**	**(0.306)**	**(0.298)**	**(0.147)**	**(0.159)**
Sargan OIR	(0.001)	(0.006)	(0.096)	(0.567)	(0.000)	(0.023)
Hansen OIR	**(0.361)**	**(0.113)**	**(0.401)**	**(0.291)**	**(0.412)**	**(0.292)**
DHT for instruments						
a)Instruments in levels						
Hansen excluding group	**(0.962)**	**(0.810)**	**(0.794)**	**(0.606)**	**(0.662)**	**(0.872)**
Dif(null, H=exogenous)	**(0.120)**	(0.034)	**(0.210)**	**(0.184)**	**(0.271)**	**(0.112)**
b)IV(years, eq(diff))						
Hansen excluding group	(0.824)	**(0.338)**	**(0.187)**	**(0.159)**	**(0.464)**	**(0.422)**
Dif(null, H=exogenous)	**(0.190)**	**(0.103)**	**(0.919)**	**(0.747)**	**(0.372)**	**(0.261)**
Fisher	**88303.18** ** *	**371145.35** ** *	**161523.90** ** *	**312930.46** ** *	**127883.26** ** *	**206004.62*** **
Instruments	41	41	32	32	41	41
Countries	45	45	38	37	45	45
Observations	412	398	160	156	412	398

Standard errors are in parenthesis. ***, ** , *: significance levels of 1%, 5%, and 10%, in that order. DHT: Variation in the Hansen Test for Instrument Subset Exogeneity. Dif: Variation. Over-identification Restrictions Test: OIR. Bold values are important in two ways. (1) Fisher statistics and calculated coefficients' importance. (2) The inability to reject the null hypotheses regarding the validity of the instruments in the Sargan and Hansen OIR tests and the absence of autocorrelation in the AR(1) and AR(2) tests. The mean value of mobile (55.024) and internet (11.802). na: not applicable because at least one estimated coefficient

needed for the computation of net effects is. The mean value of mobile (55.024) and internet (11.802). na: not applicable because at least one estimated coefficient needed for the computation of net effects is not significant. The range of mobile penetration 0.207 to 185. 559 is while the range of internet penetration is 0.031 to 74.756.

Table 4. Entrepreneurship, ICT and Inequality (Fourth set of specifications)

	Dependent variable: Income Inequality (GINI)	
	TIMEREINSOLV (TIMERIN)	
	MOBILE	INTERNET
L.GINI	**1.128*** **	**1.081*** **
	(0.012)	**(0.026)**
TIMEREINSOLV	**-0.810** **	-0.386
	(0.396)	(0.327)
MOBILE	**-0.019** **	
	(0.007)	
TIMERIN x MOB	**0.007** **	
	(0.003)	
INTERNET		**-0.043***
		(0.024)
TIMERIN x INT		0.010
		(0.010)
SSEG	-2.941	1.867
	(1.795)	(1.717)
LGDPPCAP	-0.213	-0.465
	(0.447)	(0.511)
Constant	-0.542	-1.950
	(4.595)	(4.860)
ICT Thresholds	nsa	---
AR(1)	**(0.039)**	(0.268)
AR(2)	**(0.603)**	**(0.144)**
Sargan OIR	(0.011)	(0.007)
Hansen OIR	**(0.496)**	**(0.096)**
DHT for instruments		
a)Instruments in levels		
Hansen excluding group	**(0.920)**	**(0.618)**
Dif(null, H=exogenous)	**(0.300)**	(0.054)
b)IV(years, eq(diff))		
Hansen excluding group	**(0.984)**	**(0.767)**
Dif(null, H=exogenous)	**(0.344)**	(0.055)
Fisher	**789865.69*** **	**2,220,000*** **
Instruments	35	35
Countries	36	36
Observations	344	333

Standard errors are in parenthesis. ***, ** , *: significance levels at 1%, 5% and 10% 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 and the Fisher statistics. (2) The failure to reject the null hypotheses of: (a) no autocorrelation in the AR(1) & AR(2) tests and; (b) the validity of the instruments in the Sargan and Hansen OIR tests. The mean value of mobile (55.024) and internet (11.802). na: not applicable because at least one estimated coefficient needed for the computation of net effects is not significant. nsa: not specifically applicable because an unexpected signs is apparent. The range of

mobile penetration 0.207 to 185. 559 is while the range of internet penetration is 0.031 to 74.756.

For lack of space, in order to avoid recycling the literature already highlighted in the introduction and critically engaged in Section 2, the present study has contributed to the literature in the corresponding sections by showing that the effect of doing business constraints on inclusive development outcomes is not linear but can be contingent on some critical levels of policy or moderating ICT variables. Accordingly, the findings broadly confirm the relevance of ICT in empowering people to reduce income inequality and poverty (Maidment, 2018), especially by means of mitigating constraints in the doing of business.

5.Concluding implications and future research directions

The objective of the study has been to examine how information and communication technology can be used to moderate the unfavorable effects of doing business constraints on income inequality in 48 sub-Saharan African countries for the period 2004 to 2019. The Gini coefficient has been used as the income inequality indicator whereas the ICT dynamics which have been employed include: mobile phone penetration and internet subscriptions. Ten indicators of doing business constraints have also been used. From the findings, for the most part, doing business constraints increase income inequality while ICT moderates the positive effect of doing business constraints on income inequality. Thresholds of ICT at which the doing business constraints no longer increase income inequality have been provided. At the established ICT penetration thresholds, ICT effectively moderate doing business constraints to reduce income inequality. In what follows, main policy implications are discussed.

It is relevant to note that, in accordance with the extant thresholds literature discussed in the previous section, policy thresholds in themselves constitute policy implications because these are critical masses of the moderating or policy variables that policy makers can directly act upon in order to influence the mechanism in the expected direction, especially as it pertains to the overall influence on the outcome variable. The study has established critical levels of ICT penetration at which, doing business constraints no longer promote income inequality in the sampled countries. It follows that policy makers should endeavour to make sure that ICT penetration levels in sampled countries are beyond the established thresholds in order for doing business constraints to no longer increase income inequality. However, policy makers should be knowledgeable of the perspective that the ICT penetration thresholds are contingent on the considered two ICT variables as well as ten doing business constraints indicators used for the study. It follows that in employing the recommended ICT policy thresholds, policy makers should be cognizant of the fact that their effectiveness is contingent on the specific dynamics of ICT and doing business constraints.

Overall, the findings are consistent with policy institutions (UNCTAD, 2014), because it is crucial to understand that while inclusive innovation policies can help the underprivileged and marginalized benefit from technology and innovation, they do not constitute a solution for the problems associated with poverty and social exclusion. Sustainable technology innovation can boost inclusive development and raise the general income levels of developing nations through investing in technological upgrading in the formal economy, facilitating the transfer of technology to domestic farms and businesses, bolstering national innovation capacities, and encouraging indigenous innovation. Moreover, sustainable technology innovation measures should not be exclusively limited to reaching the established ICT policy thresholds in this study. Accordingly, ICT policies should be tailored to account for the traits of the impoverished, their

lifestyles, and the things they require to better their standard of living. In addition, building institutions and appropriate incentives to encourage private sector participation in developing innovations that address the needs of the impoverished is necessary to strengthen the connections between inclusive innovation and the rest of the country's innovation system.

The findings in this study obviously leave room for future research, especially as it pertains to considering other United Nations (UN) Sustainable Development Goals (SDGs). Accordingly, while the present study has focused on income inequality which is the 10th UN SDG, future research can revisit the corresponding mechanisms and policy variables within the remit of other SDGs of the UN. Furthermore, the considered interactions could also be engaged within the framework of Agenda 2063 of the African Union in the light of corresponding inclusive and sustainable development objectives. Last but not the least, given the apparent shortcoming of the estimation technique which is designed to eliminate country-specific effects in order to better control for endogeneity (i.e., resulting from the correlation between the lagged dependent variable and country-specific effects), using the relevant country-specific techniques in order to assess the considered problem statement at country-specific levels can engender more country-specific policy implications.

Appendices

Appendix 1. List of countries (48) of the study

Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Congo. Dem. Rep., Congo. Rep., Cote d'Ivoire, Equatorial Guinea., Eritrea, Eswatini, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Soudan, Sudan, Tanzania, Togo, Uganda, Zambia and Zimbabwe

Source. Authors' construction

Appendix 2. Definitions and sources variables

Variable	Définition	Source
GINI	"The Gini coefficient is a measurement of the income distribution of a country's residents"	WIID
COSTOSTART	Cost of business start-up procedures (% of GNI per capita)	WDI (World Bank)
PROREGPROP	Procedures to register property (number)	WDI (World Bank)
STARTUPPROCED	Start-up procedures to register a business (number)	WDI (World Bank)
TIMEWAREHOUSE	Time required to build a warehouse (days)	WDI (World Bank)
TIMENFORCONTR	Time required to enforce a contract (days)	WDI (World Bank)
TIMEREGPROP	Time required to register property (days)	WDI (World Bank)
TIMESTARTBUS	Time required to start a business (days)	WDI (World Bank)
TIMEXPORT	Time to export. border compliance (hours)	WDI (World Bank)
TIMETAXES	Time to prepare and pay taxes (hours)	WDI (World Bank)
TIMEREINSOLV	Time to resolve insolvency (years)	WDI (World Bank)
INTERNET	Individuals using the Internet (% of population)	WDI (World Bank)
MOBILE	Mobile cellular subscriptions (per 100 people)	WDI (World Bank)
SSEG	School enrollment. secondary (gross). gender parity index (GPI)	WDI (World Bank)
LGDPPCAP	Logarithm of the Gross Domestic Product (GDP) per capita	WDI (World Bank)
POLS	"Political stability/no violence (estimate): measured as the perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional and violent means, including domestic violence and terrorism"	WDI (World Bank)

WDI: World Bank Development Indicators of the World Bank and WIID: World Income Inequality Database.

Appendix 3. Summary Statistics

Variable	Obs	Mean	SD	Min	Max
GINI	768	55.96	6.285	32.11	74.24
COSTOSTART	768	114.801	213.098	0	1821.9
PROREGPROP	730	6.186	1.921	3	12.31
STARTUPPROCED	730	9.318	3.169	3	18
TIMEWAREHOUSE	674	183.455	85.577	67	625
TIMENFORCONTR	730	678.997	289.812	228	1785
TIMEREGPROP	730	71.448	64.735	7	389
TIMESTARTBUS	730	39.613	38.443	2.5	260.5
TIMEXPORT	281	134.319	105.609	3.056	588
TIMETAXES	689	300.826	161.305	76	834
TIMEREINSOLV	576	2.989	0.998	1	5
INTERNET	734	11.802	14.382	0.031	74.756
MOBILE	754	55.024	39.73	0.207	185.559
SSEG	462	0.88	0.199	0.332	1.388
LGDPPCAP	743	7.147	0.956	5.599	9.726
POLS	761	-.569	0.922	-3.313	1.201

S.D: Standard Deviation

Appendix 4. Correlation matrix

	Dependent variable	Entrepreneurship dynamics										ICT		Control variable		
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) GINI	1.000															
(2) COSTOSTART	0.029	1.000														
(3) PROREGPROP	-0.145	-0.121	1.000													
(4) STARTUPPROCED	-0.025	0.074	0.475	1.000												
(5) TIMEWAREHOUSE	0.130	0.092	0.003	0.158	1.000											
(6) TIMENFORCONTR	-0.038	-0.073	0.136	0.181	-0.009	1.000										
(7) TIMEREGPROP	0.074	0.079	0.139	0.017	0.024	0.048	1.000									
(8) TIMESTARTBUS	0.075	0.054	0.281	0.578	0.246	0.084	-0.085	1.000								
(9) TIMEXPORT	-0.160	0.046	0.367	0.178	0.147	-0.051	0.291	0.188	1.000							
(10) TIMETAXES	0.017	0.307	0.040	-0.042	0.279	0.088	0.236	0.274	0.341	1.000						
(11) TIMEREINSOLV	0.015	0.391	-0.278	-0.333	-0.076	-0.028	0.169	-0.114	0.195	0.389	1.000					
(12) INTERNET	-0.189	-0.261	-0.100	-0.038	0.024	0.070	-0.273	0.085	-0.211	-0.193	-0.512	1.000				
(13) MOBILE	-0.198	-0.226	-0.174	-0.191	-0.012	-0.007	-0.295	-0.073	-0.207	-0.248	-0.452	0.854	1.000			
(14) SSEG	0.103	-0.388	-0.148	-0.028	-0.200	0.019	-0.193	-0.152	-0.284	-0.515	-0.391	0.425	0.321	1.000		
(15) LGDPPCAP	-0.243	-0.228	0.013	0.106	0.064	0.096	-0.253	0.174	-0.115	-0.216	-0.582	0.904	0.831	0.294	1.000	
(16) POLS	0.036	-0.318	-0.303	-0.027	-0.029	-0.042	-0.112	-0.076	-0.357	-0.412	-0.453	0.514	0.475	0.426	0.513	1.000

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