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Inequality, ICT and Financial Access in Africa[1]

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Inequality, ICT and Financial Access in Africa

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Abstract

This study investigates the role of information and communication technology (ICT) on income inequality through financial development dynamics of depth (money supply and liquid liabilities), efficiency (at banking and financial system levels), activity (from banking and financial system perspectives) and size, in 48 African countries for the period 1996 to 2014. The empirical evidence is based on Generalised Method of Moments. While both financial depth and size are established to reduce inequality contingent on ICT, only the effect of financial depth in reducing inequality is robust to the inclusion of time invariant variables to the set of strictly exogenous variables. We extend the analysis by decomposing financial depth into its components, namely: formal, informal, semi-formal and non-formal financial sectors. The findings based on this extension show that ICT reduces income inequality through formal financial sector development and financial sector formalization as opposed to informal financial sector development and financial sector informalization. The study contributes at the same time to the macroeconomic literature on measuring financial development and responds to the growing field of addressing post-2015 Sustainable Development Goals (SDGs) inequality challenges by means of ICT and financial access.

JEL Classification : I30; L96; O16;O55.

Keywords: Inequality; ICT; Financial development; Africa.

1. Introduction

The positioning of this paper builds on four points in the literature, notably: (i) growing exclusive development in Africa; (ii) concerns about financial access in the continent; (iii) the penetration potential of information and communication technology (ICT) and (iv) gaps in the literature. We discuss the points in chronological order.

First, exclusive development is a policy concern in Africa because after two decades of unprecedented economic prosperity and decreasing rates of extreme poverty, the number of people living in extreme poverty is still substantially higher in 2012 than it was in 1990 (Beegle et al., 2016: xi). According to the authors, it is further projected that the extremely poor of the world will be largely concentrated in Africa. Moreover, in the post-2015 development agenda, with the adoption of Sustainable Development Goals (SDGs), a solid understanding of inequality is required by regions in order to better articulate the policy agenda. The connection between the main highlighted terms or concepts is that the response of poverty to growth is a decreasing function of inequality (Fosu 2010a, 2010b). The highlighted sobering past of and prospects for Africa represent policy challenges that can be partly addressed by leveraging on the growth potential of ICT and enhancing financial access.

Second, financial development is lowest in Africa compared to other regions of the world (Tchamyou & Asongu, 2017). This is in spite of the consensus that increased financial access provides investment opportunities for both households and corporations that ultimately result in positive development externalities (Odhiambo, 2010, 2013).The intuition underpinning linkages between finance, poverty and inequality partly build on the finance and growth relationship which has been documented in the economic development literature (Kappel, 2010). Financial development mitigates information and transaction costs and hence decreases financing constraints of economic operators and households (Demirgüç-Kunt& Levine, 2009).There is an abundant supply of empirical literature supporting the evidence that financial development reduces poverty and inequality[2].

Third, while ICT penetration is reaching saturation levels in the developed world and high-end markets in other emerging countries, it still has a high penetration potential in Africa (see Penard et al., 2012). In the light of established evidence on the relevance of ICT in enhancing inclusive human development in the continent (Asongu & le Roux, 2017), policy can leverage on the underlying penetration potential to address post-2015 development challenges like

[2] See for instance Kappel (2010), Demirgüç-Kunt et al. (2008) and Claessens and Perotti (2007).

inequality. Recent technological advances like innovation, mobile money and the creation of new banking services are enhancing conditions for financial access in Africa (AfDB, 2013). Moreover, according to Andrianaivo and Kpodar (2011), ICT contributes tremendously to economic expansion in African countries. They also concluded that a portion of the positive impact of mobile phone penetration growth is associated with more financial inclusion. Furthermore, Samra and Pais (2011) posited that the level of financial inclusion and human development in a country are closely related. In addition, the relationship is contingent on important factors such as physical infrastructure (which includes ICT by definition), literacy, income and inequality.

Fourth, the extant literature has largely focused on either the ICT-development nexus (Asongu & Nwachukwu, 2017a; Chavula, 2013; Mishra & Bisht, 2013; Andrianaivo & Kpodar, 2011) or the finance-development relationship (Beck et al., 2007; Batuo et al., 2010; Shahbaz & Islam, 2011; Jalil & Feridum, 2011; Hamori & Hashiguchi, 2012; Asongu & Tchamyou, 2014). As discussed in Section 2, the attendant literature can be classified into four main categories, notably: (i) literature on finance and inclusive development; (ii) studies on information technology and inclusive development; (iii) literature on information technology and financial access and (iv) studies on the connection between information technology, financial access and inclusive development.

Our contribution to the literature is twofold: *first*, as explained in the fourth category above, the study integrates the first three categories by assessing linkages between information technology, financial access and inequality. Accordingly, the objective of the study is to examine how ICT affects inequality through financial development by employing the Generalized Method of Moments on data from 48 African countries for the period 1996-2014. *Second,* this paper also has a methodological contribution when compared to studies that are critically engaged in Section 2. In essence, in the assessment of how ICT modulates the effect of financial access on income inequality, we directly place the policy instruments (ICT indicators) in the *ivstyle* section of the GMM specification. Note should be taken of the fact that in the presentation of results, these policy channels are highlighted in the post-estimation diagnostic information criteria used to assess the validity of the overall model. In this light, the Difference in Hansen Test is directly used to assess how the policy channels affect inequality through finance. We also further assess the validity of the policy channels by changing the conception and definition of strictly exogenous variables with the classic time invariant variables that control for cross sectional dependence. A quick look at the discussion

on "*identification, simultaneity and exclusion restrictions*" underlying the GMM specification, shows that it is different from the classical discussion, because the identification process is not arbitrary but consistent with the problem statement underlying in the paper, notably: finance and control variables are specified in the *gmmstyle* section of the equation while ICT dynamics are specified in the *ivstyle* section of the equation. Overall, in the interpretation of results, the main difference with mainstream GMM papers is that we are no longer assessing the validity of ad hoc instruments (i.e. lags and first differences). Instead, we are assessing the validity of the selected ICT policy instruments.

The methodological innovation is superior to mainstream GMM approaches when a problem statement is presented such that policy variables affect a specific macroeconomic outcome through predetermined macroeconomic channels. This is essentially because the problem statement can then be tailored to align with the specification and discussion on "identification and exclusion restrictions". To put this element into greater perspective, if lags and differences of the endogenous explaining variables are used as policy instruments in the identification process, the results are interpreted as: "policy lags and differences of ICT and finance" influencing inequality through "ICT and finance" channels. This interpretation is not consistent with the problem statement because it conflates mechanisms with policy instruments and vice versa.

The rest of the study is structured as follows. Section 2 discusses the theoretical underpinnings. The data and methodology are covered in Section 3 whereas Section 4 discloses the empirical results and corresponding discussion. Section 5 presents concluding implications and future research directions.

2. Theoretical underpinnings and related literature

2.1. Theoretical underpinnings

This section highlights theoretical underpinnings on the relationship between inequality and financial access.

There are two main conflicting theories on the impact of financial development on inequality. Some views infer that financial development is essential in improving growth and decreasing inequality. Financial constraints, such as information asymmetry, transaction costs and collateral requirements can severely constraint financial access to the poor. It follows that reducing inequalities through improved efficiency in the allocation of capital would likely facilitate access to finance for the poor, especially to those with expected profitable

investments (Galor & Zeira, 1993; Aghion & Bolton, 2005; Galor & Moav, 2004). Consequently, relaxing these financial constraints would, among others: benefit the poor, boost overall growth and reduce income inequality (Beck et al., 2007).

Conversely, contending theories posit that financial development largely benefits the rich. In accordance with these theories, poor people rely on remittances and on the informal financial sector for capital (see Beck et al., 2007). The theoretical thesis and anti-thesis on the pro-poor character of financial development are synthesised by another theoretical perspective which reconciles the contending views by establishing that the underlying relationship is non-monotonic. In this third strand, Greenwood and Jovanovic (1990) have supported the idea of an inverted U-shaped nexus between inequality and financial sector development. The authors posit that at the beginning of the development process, inequality increases with financial development. This is consistent with a 'Kuznets curve' interpretation, based on the hypothesis that income inequality increases at the early stages of economic development and then decreases when reforms are taking place (Kuznets, 1955). To put this into more perspective, the relationship between the development of inclusive finance and inequality is clearly reversed, indicating that the development of inclusive finance will initially increase income gaps, and when financial development attains a high level, it will then reduce income gaps and therefore mitigate inequality. However, this relationship between inequality and finance changes over time as an economy develops, from the intermediate to the mature stage (Asongu & Tchamyou, 2014).

The above debates are reflected in both the intensive and extensive margin theories. According to the *intensive margin theory*, finance affects inequality via an indirect channel as well as a direct channel; through the improvement of financial services of agents which already have access to the formal financial system, notably: well-established corporations and wealthy individuals (Chipote et al., 2014). Conversely, the *extensive margin theory* states that financial development could operate on the extensive margin by enhancing access to and usage of financial services by agents who due to financial constraints had not been using financial services (Chiwira et al., 2016; Orji et al., 2015; Odhiambo, 2014). Put in other terms, financial development will reduce intergenerational persistence in relative incomes by improving economic opportunities for the less privileged groups (Batabyal & Chowdhury, 2015; Bae et al., 2012). This is in accordance with the *liquidity constraints theory* which posits that constraints in having access to liquidity obstruct business opportunities of the poor

and therefore increase the income inequality of economic operators (Evans & Jovanovic, 1989; Holtz-Eakin et al. 1994; Black & Lynch, 1996).

The positioning of this study is both consistent with the intensive margin and extensive margin theories. On the one hand, it aligns with the intensive margin theory in the perspective that financial access influences inequality both directly and indirectly through ICT. It is important to note that in the empirical specification in this study, ICT dynamics are defined as strictly exogenous variables. Moreover, for the exclusion restriction hypothesis underpinning this identification strategy to hold, ICT must influence inequality exclusively via the engaged financial access channels. Accordingly, as will be clarified in the methodology section, this underlying hypothesis is the Difference in Hansen test for ICT exogeneity. Within the framework of the intensive margin theory, there is an underlying assumption that the interaction between ICT and banks is exclusively limited to those with bank accounts and access to finance via formal banking institutions. However, if such interactions also involve those without bank accounts or the previously unbanked population, the extensive margin theory sets in.

On the other hand, the extensive margin theory is consistent with the positioning of this study because ICT is not exclusively used by those with formal bank accounts. Hence, ICT could be a valuable instrument with which those with financial constraints (especially the unbanked) can have access to formal financial services. Consistent with Asongu and Nwachukwu (2017b), ICT-related banking can enable the previously unbanked to have access to formal financial services if ICT is leveraged such that, *inter alia*: (i) ICT improves the store of value within the formal banking sector, given that the Subscriber Identity Module (SIM) can also play the role of a smartcard (or virtual bank card); (ii) ICT-banking enables access to bank accounts since it can also serve as an Automated Teller Machine (ATM) for transaction purposes and (iii) ICT-banking enables communications and transactions between banks and hence, serves as a Point Of Sale (POS). Accordingly, the previously unbanked population can benefit within the framework of "partially integrated ICT savings" as opposed to fundamental savings at the bank. A good example of such savings is the ICT transfer MPESA system which is used to store and exchange money with the help of formal banking institutions. In a nutshell, by encouraging partially integrated savings through ICT, both the intensive and extensive margin theories underpinning this study are feasible.

Linking the above theories with the digital revolution, a recent World Development Report (2016) on "*Digital Dividends*" posits that access to the internet is sufficient but not enough.

According to the report, maximizing the digital dividends necessitates a better understanding of the interaction between technology and other factors that are essential for economic development, namely: "*analog complements*". These factors entail: *regulations* so that companies can benefit from the internet to increase their competitiveness and therefore better innovate. *Improved skills,* in order for everyone to take full gain of digital opportunities; and *accountable institutions*, so that governments can better respond to the needs and the demands of citizens. Digital technologies can subsequently increase and strengthen these complements and hence, accelerate the speed of development. The underlying "*analog complements*" used in this study are financial access channels. The adoption of such channels is consistent with the 2014 Global Financial Development Report which states that, (i) new technologies are promising for the expansion of financial inclusion and (ii) financial inclusion is important for poverty-inequality reduction and economic development. That is why in the context of this study, we assess whether the complementarity of ICT and financial development indicators can reduce income inequality.

The contending strands in the discussed theoretical literature converge in the view that finance affects inequality (whether positively or negatively). This inquiry builds on this theoretical consensus of a relationship between finance and inequality. The theoretical relevance of ICT in the underlying relationship is motivated by the fact that the development of ICT decreases financing constraints (e.g. transaction costs and information asymmetry), boosts economic growth and helps in reducing poverty and income inequality.

Hence, the problem statement of this inquiry appears justified from a theoretical standpoint: ICT affects inequality through financial development.

2.2. Related literature: inequality, information technology and finance

This section on recent literature is discussed in four main strands: (i) finance and inclusive development; (ii) information technology and inclusive development; (iii) information technology and financial access and (iv) information technology, finance and inclusive development. The four highlighted strands are expanded in chronological order.

In the first strand on the nexus between finance and inclusive development, the 2014 Global Financial Development Report (GFDR, 2014) came up with new evidence, which shows that financial inclusion can significantly reduce poverty and improve shared prosperity,

but also stressed that efforts to promote inclusion must be well designed. Consistent with the report, Corrado and Corrado (2017) analyse the role of inclusive finance for inclusive growth and development and find that inclusive finance has many benefits on inclusive growth. Inclusive finance: (i) enables reasonable access to various financial services for everyone; (ii) gives opportunities to economic operators to make long-term investment and consumption plans; (iii) protects households and businesses against adverse shocks and (iv) provides people with opportunities to better exploit social and economic opportunities. More recently, Meniago and Asongu (2018) explore the relationship without policy variables in the light of the Kuznets hypothesis to conclude that: (i) financial access and intermediation efficiency reduce inequality and (ii) a Kuznets nexus is apparent between GDP per capita and inequality. Sarma and Pais (2011) empirically examined the relationship between economic development and financial inclusion by identifying country-specific factors that are linked to financial inclusion. They found that, in a given country, levels of financial inclusion and human development navigate closely.

Asongu and Nwachukwu (2018a) investigate the linkage between inclusive development (i.e. inequality and poverty) and mobile banking in 93 developing countries for the year 2011.They find a positive correlation between mobile banking and inclusive development when a certain threshold of the human development index is reached. Using simultaneity-robust fixed effects regressions on data from 49 Sub-Saharan African countries, Asongu and Nwachukwu (2018b) assess thresholds of quality of education at which the dissemination of information with mobile phones improves inclusive human development. They find positive marginal and net effects on inclusive development when interacting educational quality with mobile phones. They also find that, on average, a range of 10 to 27 pupils per teacher is required in primary education in order to improve inclusive human development via mobile phones. Asongu and Asongu (2018) examine the correlations between inclusive development (proxied with quality of growth, inequality and poverty) and mobile banking in 93 developing countries for the year 2011. Employing interactive ordinary least squares, results show that the increasing usage of mobile phones to pay bills has a positive relationship with quality of growth in low-middle income countries. However, the correlation with inequality in Latin American countries is negative. The authors also find a negative association with the increasing use of mobile phones to receive and send money and poverty in two regions, notably: “Asia and the Pacific” and “Central and Eastern Europe”.

Asongu and Odhiambo (2017) have employed interactive quantiles regressions to investigate the correlations between inclusive development and mobile banking throughout the conditional distribution of inclusive development. They have found that for the most part, increasing of mobile banking mechanisms to certain thresholds would also increase quality of growth and decrease inequality at the top-end of the inclusive development distribution. They have recommended that encouraging usage of mobile banking applications will play a significant role in responding to challenges of exclusive growth, inequality and poverty in developing countries. Asongu (2015a) complemented the qualitative and theoretical literature with empirical evidence on the income-redistributive effects of the penetration of mobile phones in 52 countries in Africa. The author employed two empirical techniques, namely the ordinary least squares and the two stage least squares. The findings suggest that the penetration of mobile phones is pro-poor. More insights into this strand are apparent in a recent special issue on mobile technologies for inclusive development in Africa (Asongu & Boateng, 2018).

In the third strand on the relationship between information technology and financial access, using Generalised Method of Moments and Quantile Regressions as empirical techniques in a panel of 162 banks, Asongu et al. (2018) assess how the diffusion of information mitigates the negative effect of market power on the quantity and price of loans. The authors provide policy thresholds at which the modulating effect of information diffusion on market power can improve access to finance in Africa. Peruta (2017) employs a macroeconomic approach with cluster analysis to investigate whether the adoption of mobile money services is high in countries where access to formal banking services is low. Contrary to previous studies, results do not support the idea that mobile money usage promotes financial inclusion. In order to investigate if mobile money can help firms reduce financial access constraints, Gosavi (2018) uses the World Bank's Enterprise Surveys Program data for the year 2013 in Eastern sub-Saharan Africa. Results show that companies, which are using mobile money, have the advantage of easily getting lines of credit or loans. Further analysis reveals that firms using mobile money are productive compared to other companies in the sub-region. Bongomin et al. (2018) have tested the moderating effect of social networks in the linkage between financial inclusion and mobile money usage in rural Uganda. Results indicate a positive and significant moderating effect of social networks in the connection between the usage of mobile money and financial inclusion in rural Uganda.

Abor et al. (2018) in fourth strand have employed an instrumental variable technique and a seemingly unrelated probit model to assess two main objectives: (i) investigate whether

access to a wide range of financial services improves the ability of households to live a dignified life and (ii) analyze whether mobile telephony stimulates pro-poor development by helping households in poverty alleviation and the efficient allocation of consumption. The findings show that financial inclusion and mobile phone penetration substantially decrease the likelihood of a household to become poor and per capita consumption of non-food and food products. Estimating the economic growth model using time-series and cross-country data from 62 countries over the period 2000-2006, Yousefi (2011) found that the effect of economic growth on ICT varies from different income groups. The author concluded that ICT plays a significant role in the growth of high and upper-middle income groups. However, ICT failed to contribute to the growth of lower-middle income group.

Consistent with the motivation of the study, the contribution of the study to the engaged literature is in the fourth strand. Hence, we integrate the three strands by assessing linkages between information technology, financial access and inequality.

3. Data description and Estimation techniques

3.1. Data description

To investigate how ICT influences inequality through financial access, we are consistent with Tchamyou (2018a, 2018b) in combining four sources of data, namely: (i) the Global Consumption and Income Project (GCIP) for inclusive variables; (ii) the Financial Development and Structure Database (FDSD) of the World Bank for financial access variables; (iii) the World Development Indicators (WDI) of the World Bank for ICT and control variables and (iv) the World Governance Indicators (WGI) of the World Bank for governance control variables.

South Sudan is not included for two main reasons: (i) the country is missing in the FDSD and (ii) data for this country is only available from the year 2011. Moreover, data for South Sudan, Equatorial Guinea, Eritrea, Libya, Somalia and Zimbabwe are not available in the GCIP. It is also important to note that data for the Gambia is up to 2013. The starting date is 1996because it is the starting year of governance variables and the ending date is 2014 due to data availability constraints. Hence, we obtain an unbalanced dataset consisting of 48 African countries for the period 1996-2014.

Three dependent variables for individual income inequality are used, namely: the Gini coefficient, the Palma ratio and the Atkinson index. The first is used for the baseline

regressions whereas the last-two are employed for robustness checks. A zero Gini coefficient represents perfect equality whereas a corresponding value of one denotes the highest level of inequality. Interest in the Palma ratio has been increasing over the past years and the ratio has been proposed to be included in the United Nations post-2015 global development agenda. In addition, the Palma ratio is currently proposed as a standard measure of inequality by the annual Human Development Report of the United Nations Development Programme (UNDP) and by the Income Distribution Database of the Organization for Economic Co-operation and Development (OECD). One of the advantages of the Palma ratio is that it captures the tails of the distribution (i.e. the poorest and the richest), while the Gini mainly focuses on the entire distribution (Cobham et al., 2015).

Consistent with Efobi et al. (2018); Sassi and Goaied (2013); and Chavula (2013), we employ mobile phone penetration rate per 100 people, internet penetration rate per 100 people and fixed broadband subscription per 100 people as proxies for ICT. Furthermore, in its publication of 2012 on "*Boosting development with broadband and ICTs*", the United Nations Development of Economic and Social Affairs (UNDESA) stressed the importance of enhancing broadband and ICTs, particularly mobile phone and internet connection in order to fight famine and poverty around the world. It latter argued that broadband may be of help in boosting income and Gross Domestic Product (GDP) (UNDESA, 2012). Financial efficiency (from banking and financial system perspectives), financial activity (at banking and financial system levels), financial depth (money supply and financial system deposits or liquid liabilities) and financial size are used as measurements of financial access (Sahay et al., 2015; Svirydzenka, 2016; Asongu et al. 2016; Tchamyou & Asongu, 2017). In accordance with the finance and inequality literature, we control for remittances (Ssozi & Asongu, 2016), primary school enrolment (Beck et al., 2007), corruption control and government consumption expenditure. Whereas remittances are used for consumptions purposes for the most part and can be expected to decrease inequality, the actual effect on income distribution depends on whether a great bulk of the remittances are destined to the poor factions of the population. While, compared to other levels of education, primary education has been documented to positively affect development externalities in countries at initial stages of industrialisation (Asiedu, 2014), the overall outcome may be contingent on a number of factors, such as: the education quality in a country and importance of primary education in the job market relative to other educational levels. The control of corruption is an institutional governance factor that is expected to decrease inequality. Unfortunately, the policy variable may be highly skewed to the left side of the distribution and produce the opposite effect. This unexpected scenario can

be consolidated with the positive sign from government expenditure if funds allocated for the running of government activities are misallocated, mismanaged and siphoned by corrupt government officials.

The definitions of variables are presented in Table 1 while Table 2 and Table 3 respectively display summary statistics with the presentation of countries and the correlation matrix.
Two main points are apparent from the summary statistics: (i) from mean values, variables are comparable and (ii) from standard deviations, there is a substantial variation between indicators, hence we can expect reasonable relationships to emerge from the estimations. The aim of the correlation matrix is to control for issues of multicollinearity among variables. This concern is apparent in inequality variables on the one hand and on the other hand in financial development variables. To avoid conflicting results, financial development indicators are not specified in the same model and inequality variables are used distinctly as dependent variables.

Table 1: Definitions and sources of variables

Variables	Signs	Definitions	Sources
Income Inequality	Gini Index	"*The Gini index is a measurement of the income distribution of a country's residents*".	GCIP
	Atkinson	"*The Atkinson index measures inequality by determining which end of the distribution contributed most to the observed inequality*".	GCIP
	Palma ratio	"*The Palma ratio is defined as the ratio of the richest 10% of the population's share of gross national income divided by the poorest 40%'s share*".	GCIP
Economic Financial Depth	M2	Money Supply (% of GDP)	World Bank (FDSD)
Financial System Depth	Fdgdp	Liquid Liabilities (% of GDP)	World Bank (FDSD)
Banking System Efficiency	BcBd	Bank credit on Bank deposits	World Bank (FDSD)
Financial System Efficiency	FcFd	Financial credit on Financial deposits	World Bank (FDSD)
Banking System Activity	Pcrb	Private domestic credit from deposit banks (% of GDP).	World Bank (FDSD)
Financial System Activity	Pcrbof	Private domestic credit from financial institutions (% of GDP).	World Bank (FDSD)
Financial Size	Dbacba	Deposit bank assets on Central bank assets plus Deposit bank assets.	World Bank (FDSD)
ICT	Mobile Phone	Mobile phone subscriptions (per 100 people).	World Bank (WDI)
	Internet	Internet subscriptions (per 100 people).	World Bank (WDI)
	Fixed Broadband	Fixed Broadband (per 100 people).	World Bank (WDI)

Government Consumption Expenditure	GCE	General government final consumption expenditure (% of GDP).	World Bank (WDI)
Primary School Enrolment	PSE	School enrolment, primary (gross), gender parity index (GPI).	World Bank (WDI)
Remittances	Remit	Remittance inflows to GDP (%)	World Bank (WDI)
Corruption Control	CC	"*Control of Corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5*".	World Bank (WGI)

WDI: World Bank Development Indicators. WGI: World Bank Governance Indicators. FDSD: Financial Development and Structure Database. GCIP: Global Consumption and Income Project.

Table 2: Summary Statistics (1996-2014) and Presentation of countries

Panel A: Summary statistics

	Variables	Mean	S.D.	Min.	Max.	Obs.
Income Inequality	Gini Index	0.587	0.041	0.488	0.868	911
	Atkinson	0.701	0.060	0.509	0.895	911
	Palma ratio	6.454	1.749	3.016	21.790	911
Financial Development	Economic Financial Depth (M2)	32.680	21.779	4.129	108.90	861
	Financial System Depth (Fdgdp)	26.272	20.610	1.690	97.823	862
	Banking System Efficiency (BcBd)	71.340	29.189	13.754	186.72	876
	Financial System Efficiency (FcFd)	0.756	0.391	0.137	2.606	862
	Banking System Activity (Pcrb)	18.829	17.630	0.551	102.54	862
	Financial System Activity (Pcrbof)	20.707	23.575	0.551	150.21	862
	Financial Size (Dbacba)	73.169	23.115	2.982	100.00	870
ICT	Mobile Phone Penetration	29.240	36.942	0.000	171.38	907
	Internet Penetration	5.558	9.740	0.000	56.800	893
	Fixed Broadband	0.708	1.873	0.000	14.570	462
Control variables	Government Consumption Expenditure	14.988	6.164	2.057	63.935	817
	Primary School Enrolment	0.901	0.114	0.497	1.139	754
	Corruption control	-0.554	0.567	-2.057	1.249	767
	Remittances	4.011	7.248	0.000	61.988	773

Panel B: Presentation of countries

Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Chad, Central African Republic, Comoros, Congo Democratic Republic, Congo Republic, Côte d'Ivoire, Djibouti, Egypt, Ethiopia, Gabon, The Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Senegal, Sierra Leone, Sudan, Rwanda, Sao Tomé & Principe, Seychelles, South Africa, Swaziland, Tanzania, Togo, Tunisia, Uganda, Zambia.

S.D: Standard Deviation. Min: Minimum. Max: Maximum. Obs.: Observations. M2: Money Supply. Fdgdp: Financial deposits(liquid liabilities). BcBd: Bank credit on Bank deposits. FcFd: Financial credit on Financial deposits. Pcrb: Private domestic credit from deposit banks. Pcrbof: Private domestic credit from deposit banks and other financial institutions. Dbacba: Deposit bank assets on central bank assets plus deposit bank assets. ICT: Information and Communication Technology.

Table 3: Correlation matrix (uniform sample size)

Income Inequality			ICT			Financial Development Dynamics							Control variables				
						Financial Depth		Fin. Efficiency		Financial Activity		Fin.Size					
Gini	Atkinson	Palma-r	Mobile	Internet	Broadbd	M2	Fdgdp	BcBd	FcFd	Prcb	Pcrbof	Dbacba	CC	Remit	GCE	PSE	
1.000	0.881	0.967	0.050	0.000	-0.089	-0.289	-0.251	0.144	0.143	-0.123	-0.125	-0.126	0.268	0.057	0.131	0.267	Gini-Inc
	1.000	0.922	0.009	-0.025	-0.114	-0.280	-0.231	0.103	0.100	-0.117	-0.117	-0.088	0.236	0.112	0.087	0.183	Atkin-Inc
		1.000	0.073	-0.010	-0.104	-0.283	-0.242	0.088	0.086	-0.144	-0.147	-0.101	0.322	0.065	0.136	0.277	Palma-Inc
			1.000	0.768	0.621	0.278	0.275	0.016	0.009	0.329	0.322	0.239	0.350	0.022	0.192	0.387	MobilePhone
				1.000	0.724	0.438	0.434	0.091	0.085	0.516	0.512	0.174	0.346	0.095	0.207	0.341	Internet
					1.000	0.333	0.344	0.032	0.024	0.435	0.430	0.157	0.409	-0.070	0.209	0.264	Broadbd
						1.000	0.988	0.034	-0.029	0.810	0.816	0.379	0.348	0.172	-0.009	0.148	M2
							1.000	-0.014	-0.008	0.835	0.841	0.393	0.393	0.142	-0.004	0.194	Fdgdp
								1.000	0.994	0.468	0.465	0.355	0.074	-0.006	0.044	-0.210	BcBd
									1.000	0.465	0.466	0.345	0.069	-0.022	0.051	-0.190	FcFd
										1.000	0.998	0.482	0.426	0.121	0.045	0.147	Prcb
											1.000	0.479	0.428	0.116	0.044	0.156	Pcrbof
												1.000	0.148	-0.050	-0.048	-0.114	Dbacba
													1.000	-0.057	0.303	0.398	CC
														1.000	-0.195	0.021	Remit
															1.000	0.012	GCE
																1.000	PSE

Gini-Inc: Gini of Income Inequality. Atkin-Inc: Atkinson of Income Inequality. Palma-Inc: Palma ratio of Income Inequality. M2: Money Supply. Fdgdp: Financial deposits(liquid liabilities). BcBd: Bank credit on Bank deposits. FcFd: Financial credit on Financial deposits. Pcrb: Private domestic credit from deposit banks. Pcrbof: Private domestic credit from deposit banks and other financial institutions. Dbacba: Deposit bank assets on central bank assets plus deposit bank assets. CC: Corruption-Control. Remit: remittances. GCE: Government Consumption Expenditure. PSE: Primary School Enrolment.

3.2. Estimation technique

The empirical technique adopted in this study is the Generalized Method of Moments (GMM) with forward orthogonal deviations. There are four main points motivating the choice of this estimation technique. First, this estimation strategy has the advantage of dealing with endogeneity by controlling for (i) time invariant omitted variables and (ii) simultaneity (with the instrumentation process). Second, the number of cross sections (N=48) is higher than the number of time series in each cross section (T=19), therefore N>T. Third, the inequality variables are persistent because their respective correlations with their first lags are higher than 0.800 which is the rule of thumb for establishing persistence. Finally, our panel data structure is consistent the GMM method, which implies that cross-country differences are taken into account in the analysis. The specification is based on the Roodman (2009a, 2009b): an extension of Arellano and Bover (1995) which has been reported to control for cross sectional dependence and to restrict instrument proliferation (see Baltagi, 2008; Tchamyou & Asongu, 2017).To control for heteroscedasticity, a *two-step* procedure is chosen in the modelling exercises in place of the *one-step* approach.

The standard GMM equations in levels (1) and in first difference (2) can be summarised as follows:

$$INC_{i,t} = \sigma_0 + \sigma_1 INC_{i,t-\tau} + \sigma_2 FD_{i,t} + \sum_{h=1}^{k} \delta_h W_{h,i,t-\tau} + \eta_i + \xi_t + \varepsilon_{i,t} \quad (1)$$

$$INC_{i,t} - INC_{i,t-\tau} = \sigma_1 (INC_{i,t-\tau} - INC_{i,t-2\tau}) + \sigma_2 (FD_{i,t} - FD_{i,t-\tau}) + \sum_{h=1}^{k} \delta_h (W_{h,i,t-\tau} - W_{h,i,t-2\tau}) + (\xi_t - \xi_{t-\tau}) + (\varepsilon_{i,t} - \varepsilon_{i,t-\tau}) \quad (2)$$

where, $INC_{i,t}$ is income inequality in country i at period t; $FD_{i,t}$ is the financial development in country i at period t; σ_0 is a constant; τ represents the coefficient of auto-regression which is one in our case; W is the vector of control variables , η_i is the country-specific effects, ξ_t is the time-specific constant and $\varepsilon_{i,t}$ the error term. It is important to note that in the presentation of equations, instruments are not explicitly disclosed. Hence, the ICT variables which are considered to exhibit strict exogeneity are not disclosed in Eq. (1) and Eq. (2).

3.3. Identification, simultaneity and exclusion restrictions

It is important to discuss key aspects of the GMM estimation technique, namely: identification; simultaneity and exclusion restrictions.

First, the identification approach is in accordance with Dewan and Ramaprasad (2014) and Tchamyou and Asongu (2017). While they have largely employed years as strictly exogenous variables, we consider ICT to exhibit strict exogeneity, in accordance with our line of inquiry: the role of ICT on inclusive development through financial access. Hence, on the one hand, ICT is adopted independently as strictly exogenous variables and on the other hand, ICT is complemented with years in the conception of strictly exogenous variables. The motivation for including the time invariant variables to ICT is consistent with the underlying literature, notably: it is not feasible for the time invariant variables to be endogenous after first difference (Roodman, 2009b). It follows that the corresponding predetermined or suspected endogenous variables represent the channels via which ICT affects inclusive development, namely through financial access. Hence, in the GMM specification, the procedure employed for ICT and the time invariant omitted indicators (or *ivstyle*) is 'iv(ICT, years, eq(diff))' while the procedure for examining the predetermined variables is the *gmmstyle.*

Second, as opposed to forward differenced measures, the concern of simultaneity is solved with lagged explanatory variables as instruments. Given that fixed effects are correlated with the error terms, Helmet conversions are used to remove those fixed effects to avoid obtaining biased estimations (Arellano & Bover, 1995; Love & Zicchino, 2006). The transformation which is different from the procedure of subtracting prior observations from current ones embodies the usage of forward mean-variations. Concretely, the mean of expected observations is deducted from precedent observations (Roodman, 2009b). These transformations allow orthogonal or parallel conditions between lagged observations and forward-differenced indicators. In addition, to avoid losing data, the transformations are computed for all observations except for the last year in each country.

Third, with regards to the exclusion restrictions, the adopted strictly exogenous variables (ICT and time invariant indicators) have an effect on the dependent variable exclusively through the suspected endogenous variables. Moreover, the statistical validity related to the exclusion restrictions is examined with the Difference in Hansen Test for the relevance of instruments. In theory, the null hypothesis should not be rejected for the variables exhibiting strict exogeneity to explain the dependent variable only through the endogenous explaining

variables. It is essential to note that in the instrumental variable method, when the null hypothesis of the Sargan Overidentifying Restrictions test is rejected, it implies that the dependent variable is not exclusively explained by the instruments via the predetermined variables (Beck et al., 2003).However, the Difference in Hansen Test is the information criterion needed to investigate if ICT is strictly exogenous in the GMM estimation technique with forward orthogonal deviations. Therefore, for such an assumption of strict exogeneity to hold, the alternative hypothesis of the Difference in Hansen associated with instrumental variable (ICT, year, eq(diff)) is rejected.

In the light of the above, it is important to clarify that the indirect effects being investigated are not apparent in the specifications. Accordingly, the ICT policy instruments are disclosed in the information criteria used to validate the models. For instance, in Table 4 the ICT policy instruments are highlighted in green colour as "IV (ICT, eq (diff))". Moreover, whereas the specifications can be viewed as direct effects, the study is not based on direct effects because it assesses how ICT policy instruments influence inequality through channels of financial development. Therefore, the independent variables of interest disclosed in the specifications are mechanisms through which ICT affects inequality.

4. Empirical results and discussions

4.1. ICT-driven financial access and income inequality

Table 4 and Table 5 respectively present results for ICT-driven financial access and income inequality without time effects and with time effects. Therefore, in Table 4 only ICT variables are strictly exogenous whereas in Table 5 both ICT and time invariant variables are strictly exogenous. Each table consists of three sets of specifications: Panel A, Panel B and Panel C respectively show findings based on the Gini index, the Atkinson index and the Palma ratio. In each panel of each table, financial access variables are specified independently because of their high degrees of substitution (see Table 3). Four statistical tests are used to evaluate the validity of the model (Asongu & De Moor, 2017)[3].From these criteria two aspects are worth articulating further. On the one hand, the second-order Arellano and Bond autocorrelation test

[3]"*First, the null hypothesis of the second-order Arellano and Bond autocorrelation test (AR(2)) in difference for the absence of autocorrelation in the residuals should not be rejected. Second the Sargan and Hansen over identification restrictions (OIR) tests should not be significant because their null hypotheses are the positions that instruments are valid or not correlated with the error terms. In essence, while the Sargan OIR test is not robust but not weakened by instruments, the Hansen OIR is robust but weakened by instruments. In order to restrict identification or limit the proliferation of instruments, we have ensured that instruments are lower than the number of cross sections in most specifications. Third, the Difference in Hansen Test (DHT) for exogeneity of instruments is also employed to assess the validity of results from the Hansen OIR test. Fourth, a Fischer test for the joint validity of estimated coefficients is also provided*." (Asongu & De Moor, 2016, p.200).

in difference takes precedence over the first-order because studies in the literature exclusively rely on second-order test (Narayan et al., 2011). On the other hand, the Hansen test is preferred to the Sargan test and such a preference is justified with the rule of thumb that the number of instruments is less than the corresponding number of cross sections in every specification. It is important to note that the Sargan test is not robust but not weakened by instruments whereas the Hansen test is robust and weakened by instruments. Hence, the robust test can be adopted and the rule of thumb on avoiding the proliferation of instruments respected.

Table 4: ICT-driven financial access and Income Inequality (without time effects)

	Panel A: Gini Index						
	Financial Depth		Financial Efficiency		Financial Activity		Fin. Size
	Money Supply M2(llgdp)	Liquid Liabilities Fdgdp	Banking sys. Efficiency BcBd	Financial sys. Efficiency FcFd	Banking sys. Activity Pcrob	Financial sys. Activity Pcrobof	Dbacba
Constant	**0.083*** **	**0.066*** **	**0.087*** **	**0.084*** **	**0.098*** **	**0.098*** **	**0.110*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Gini(-1)	**0.847*** **	**0.864*** **	**0.850*** **	**0.854*** **	**0.821*** **	**0.815*** **	**0.808*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Money Supply	**-0.0001** **	---	---	---	---	---	---
	(0.016)						
Liquid Liabilities	---	**-0.0001*** **	---	---	---	---	---
		(0.003)					
Banking Sys. Efficiency	---	---	0.00004	---	---	---	---
			(0.570)				
Financial Sys. Efficiency	---	---	---	0.003	---	---	---
				(0.671)			
Banking Sys. Activity	---	---	---	---	0.00002	---	---
					(0.394)		
Financial Sys. Activity	---	---	---	---	---	0.00003	---
						(0.252)	
Financial Size	---	---	---	---	---	---	**-0.00006** **
							(0.015)
Government Expenditure	0.0001	0.0001	0.0001	0.0001	**0.0003** **	**0.0004*** **	0.00008
	(0.181)	(0.158)	(0.432)	(0.479)	**(0.016)**	**(0.005)**	(0.626)
Education	0.008	0.015	-0.004	-0.004	-0.001	0.0003	0.004
	(0.497)	(0.216)	(0.656)	(0.697)	(0.915)	(0.973)	(0.628)
Corruption-Control	**0.004** **	**0.004** **	**0.004***	0.004	0.002	0.002	0.001
	(0.018)	**(0.017)**	**(0.054)**	(0.120)	(0.151)	(0.201)	(0.329)
Remittances	**0.0003** **	**0.0003** **	0.0002	0.0003	**0.0003** **	**0.0003** **	0.0001
	(0.043)	**(0.031)**	(0.430)	(0.343)	**(0.050)**	**(0.045)**	(0.411)
Time Effects	No	No	No	No	No	No	No
AR(1)	**(0.253)**	**(0.253)**	**(0.264)**	**(0.264)**	**(0.270)**	**(0.270)**	**(0.268)**
AR(2)	**(0.324)**	**(0.338)**	**(0.285)**	**(0.288)**	**(0.314)**	**(0.318)**	**(0.322)**
Sargan OIR	**(0.559)**	**(0.507)**	**(0.643)**	**(0.696)**	**(0.147)**	**(0.164)**	**(0.700)**
Hansen OIR	**(0.690)**	**(0.723)**	**(0.804)**	**(0.869)**	**(0.785)**	**(0.811)**	**(0.828)**
DHT for instruments							
(a) GMM Instruments for levels							
H excluding group	**(0.551)**	**(0.550)**	**(0.613)**	**(0.651)**	**(0.675)**	**(0.656)**	**(0.615)**
Dif(null, H=exogenous)	**(0.655)**	**(0.702)**	**(0.771)**	**(0.845)**	**(0.693)**	**(0.749)**	**(0.805)**
(b) gmm (lagged values)	---	---	---	---	---	---	---
H excluding group							
Dif(null, H=exogenous)							
(c) IV (ICT, eq (diff))							
H excluding group	**(0.739)**	**(0.718)**	**(0.674)**	**(0.750)**	**(0.755)**	**(0.755)**	**(0.746)**
Dif(null, H=exogenous)	**(0.331)**	**(0.453)**	**(0.883)**	**(0.926)**	**(0.546)**	**(0.641)**	**(0.743)**
Fisher	**340.66*** **	**448.97*** **	**328.01*** **	**257.36*** **	**309.39*** **	**329.52*** **	**330.17*** **
Instruments	26	26	26	26	26	26	26
Countries	42	42	42	42	42	42	42

Observations	456	456	457	456	456	456	455
	Panel B: Atkinson						
	Financial Depth		Financial Efficiency		Financial Activity		Fin. Size
	Money Supply M2	Liquid Liabilities Fdgdp	Banking sys. Efficiency BcBd	Financial sys. Efficiency FcFd	Banking sys. Activity Pcrob	Financial sys. Activity Pcrobof	Dbacba
Constant	-0.033	**-0.051****	**0.044****	0.027	**-0.036***	-0.035	-0.008
	(0.132)	**(0.033)**	**(0.025)**	(0.191)	**(0.083)**	0.101	(0.747)
Atkinson (-1)	**1.011*****	**1.031*****	**0.917*****	**0.941*****	**1.011*****	**1.008*****	**(0.959*****
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Financial access	-0.00003	-0.0001	-0.00006	-0.007	0.00001	0.00003	**-0.0001*****
	(0.745)	(0.228)	(0.395)	(0.269)	(0.709)	(0.271)	**(0.002)**
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	No	No	No	No	No	No	No
AR(1)	(0.052)	(0.051)	(0.050)	(0.052)	(0.067)	(0.071)	(0.055)
AR(2)	**(0.123)**	**(0.055)**	**(0.731)**	**(0.498)**	**(0.027)**	**(0.029)**	**(0.133)**
Sargan OIR	(0.003)	(0.003)	(0.074)	(0.073)	(0.000)	(0.000)	**(0.140)**
Hansen OIR	**(0.632)**	**(0.572)**	**(0.266)**	**(0.357)**	**(0.471)**	**(0.598)**	**(0.316)**
DHT for instruments							
(a) GMM Instruments for levels							
H excluding group	**(0.319)**	**(0.324)**	**(0.444)**	**(0.424)**	**(0.344)**	**(0.375)**	**(0.231)**
Dif(null, H=exogenous)	**(0.791)**	**(0.710)**	**(0.208)**	**(0.324)**	**(0.549)**	**(0.690)**	**(0.455**
(b) gmm (lagged values)	---	---	---	---	---	---	---
H excluding group							
Dif(null, H=exogenous)							
(c) IV (ICT, eq (diff))							
H excluding group	**(0.468)**	**(0.426)**	**(0.401)**	**(0.530)**	**(0.333)**	**(0.449)**	**(0.308)**
Dif(null, H=exogenous)	**(0.899)**	**(0.834)**	**(0.132)**	**(0.126)**	**(0.820)**	**(0.843)**	**(0.376)**
Fisher	**426.41*****	**398.86*****	**477.53*****	**495.40*****	**373.40*****	**436.84*****	**394.18*****
Instruments	26	26	26	26	26	26	26
Countries	42	42	42	42	42	42	42
Observations	456	456	457	456	456	456	455
	Panel C: Palma ratio						
	Financial Depth		Financial Efficiency		Financial Activity		Fin. Size
	Money Supply M2	Liquid Liabilities Fdgdp	Banking sys. Efficiency BcBd	Financial sys. Efficiency FcFd	Banking sys. Activity Pcrob	Financial sys. Activity Pcrobof	Dbacba
Constant	**1.103****	0.669	**1.107***	**1.271***	0.632	**0.765****	**1.490*****
	(0.020)	(0.156)	**(0.069)**	**(0.060)**	(0.133)	**(0.033)**	**(0.001)**
Palma ratio (-1)	**0.643*****	**0.665*****	**0.650*****	**0.644*****	**0.660*****	**0.656*****	**0.625*****
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Financial access	-0.001	-0.001	-0.0006	-0.091	-0.0003	0.00001	**-0.005****
	(0.640)	(0.691)	(0.857)	(0.799)	(0.812)	(0.991)	**(0.029)**
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	No	No	No	No	No	No	No
AR(1)	(0.064)	(0.066)	(0.080)	(0.085)	(0.091)	(0.091)	(0.077)
AR(2)	**(0.384)**	**(0.375)**	**(0.406)**	**(0.411)**	**(0356)**	**(0.351)**	**(0.338)**
Sargan OIR	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.008)
Hansen OIR	**(0.627)**	**(0.479)**	**(0.884)**	**(0.903)**	**(0.772)**	**(0.806)**	**(0.865)**
DHT for instruments							
(a)GMM Instruments for levels							
H excluding group	**(0.639)**	**(0.658)**	**(0.474)**	**(0.542)**	**(0.639)**	**(0.654)**	**(0.576)**
Dif(null, H=exogenous)	**(0.498)**	**(0.310)**	**(0.955)**	**(0.948)**	**(0.702)**	**(0.743)**	**(0.885)**
(b) gmm (lagged values)	---	---	---	---	---	---	---
H excluding group							
Dif(null, H=exogenous)							
(c) IV (ICT, eq (diff))							
H excluding group	**(0.565)**	**(0.489)**	**(0.781)**	**(0.778)**	**(0.695)**	**(0.701)**	**(0.737)**
Dif(null, H=exogenous)	**(0.574)**	**(0.367)**	**(0.898)**	**(0.994)**	**(0682)**	**(0.801)**	**(0.947)**
Fisher	**152.05*****	**153.71*****	**252.78*****	**213.56*****	**97.74*****	**289.69*****	**270.13*****
Instruments	26	26	26	26	26	26	26
Countries	42	42	42	42	42	42	42
Observations	456	456	457	456	456	456	455

***,**,*: 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 Wald 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.

In the light of the discussed information criterion, the following findings can be established from Table 4. Only financial dynamics of depth and size mitigate the Gini index contingent on ICT. The significant effect from financial size is robust to alternative measurements of inequality in Panels B and C. The other financial development variables do not significantly affect inequality across panels. When time invariant variables are added to ICT variables in the conception and definition of strictly exogenous variables, three main tendencies become apparent in Table 5. First, the effect of financial depth on inequality is consistently negative across panels. Second, the negative effect of financial size is only confirmed in Panel B in relation to the Atkinson index. Third, whereas financial allocation efficiency is not consistently positive across panels, the positive effect of financial activity is only apparent with regard to the Gini index in Panel A.

We notice that the control variables are overwhelmingly significant with positive signs. Our expectation of negative signs far outweighs our expectation of positive signs. We investigate if the positive signs are not the result of a juxtaposition of stationary with non-stationary variables. The units root tests overwhelmingly show that the variables are stationary[4]. The justification of expected positive signs has been discussed in the data section. We do not engage the control variables further because they are not of policy relevance in the light of the inquiry.

After comparing and contrasting the findings of Table 4 with those of Table 5, it is apparent that only the effect of financial depth in reducing inequality is robust to the inclusion of time invariant variables. With the understanding that financial depth encompasses the formal, semi-formal and informal financial sectors, we extend the analysis by decomposing financial depth into its main constituents, namely: the formal, semi-formal and informal financial sectors. It is important to note that whereas money supply captures the three financial sectors, financial system deposits represent the formal and semi formal financial sectors.

[4]The unit root tests are based on Im-Pesaran-Shin and Fisher types because the Breitung and Levin-Lin and Chu tests require a strongly balanced dataset.

Table 5: ICT-driven finance access and Income Inequality (with time effects)

Panel A: Gini Index

	Financial Depth		Financial Efficiency		Financial Activity		Fin. Size
	Money Supply M2	Liquid Liabilities Fdgdp	Banking sys. Efficiency BcBd	Financial sys. Efficiency FcFd	Banking sys. Activity Pcrob	Financial sys. Activity Pcrobof	Dbacba
Constant	**0.121*** **	**0.114*** **	**0.056*** **	**0.063*** **	**0.057*** **	**0.060*** **	**0.056*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Gini(-1)	**0.776*** **	**0.793*** **	**0.843*** **	**0.837*** **	**0.858*** **	**0.848*** **	**0.811*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Money Supply	**-0.0001*** **	---	---	---	---	---	---
	(0.001)						
Liquid Liabilities	---	**-0.0002*** **	---	---	---	---	---
		(0.000)					
Banking Sys. Efficiency	---	---	**0.0001** **	---	---	---	---
			(0.038)				
Financial Sys. Efficiency	---	---	---	**0.010** **	---	---	---
				(0.031)			
Banking Sys. Activity	---	---	---	---	**0.00006*** **	---	---
					(0.005)		
Financial Sys. Activity	---	---	---	---	---	**0.00006** **	---
						(0.045)	
Financial Size	---	---	---	---	---	---	**0.0001** **
							(0.011)
Government Expenditure	**0.0003** **	**0.0003** **	-0.0001	-0.0001	**-0.0003*** **	**-0.0004*** **	-0.0002
	(0.017)	**(0.032)**	(0.233)	(0.256)	**(0.000)**	**(0.000)**	(0.100)
Education	**0.014***	**0.012***	**(0.025** **	**0.023***	**0.027*** **	**0.030*** **	**0.044*** **
	(0.062)	**(0.066)**	**(0.045)**	**(0.079)**	**(0.004)**	**(0.001)**	**(0.000)**
Corruption-Control	**0.002***	**0.002***	0.002	0.003	**0.003*** **	0.001	-0.001
	(0.079)	**(0.097)**	(0.143)	(0.119)	**(0.004)**	(0.119)	(0.269)
Remittances	**0.0003*** **	**0.0003*** **	**0.0005*** **	**0.0005*** **	**0.0004** **	**0.0004** **	**0.0004** **
	(0.005)	**(0.009)**	**(0.000)**	**(0.000)**	**(0.038)**	**(0.041)**	**(0.033)**
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AR(1)	**(0.269)**	**(0.268)**	**(0.272)**	**(0.269)**	**(0.270)**	**(0.272)**	**(0.271)**
AR(2)	**(0.322)**	**(0.323)**	**(0.368)**	**(0.360)**	**(0.336)**	**(0.346)**	**(0.400)**
Sargan OIR	(0.078)	(0.062)	**(0.106)**	**(0.104)**	(0.009)	(0.010)	**(0.121)**
Hansen OIR	**(0.480)**	**(0.400)**	**(0.445)**	**(0.459)**	**(0.320)**	**(0.385)**	**(0.343)**
DHT for instruments							
(a) GMM Instruments for levels							
H excluding group	**(0.605)**	**(0.575)**	**(0.466)**	**(0.616)**	**(0.373)**	**(0.397)**	**(0.238)**
Dif(null, H=exogenous)	**(0.328)**	**(0.261)**	**(0.401)**	**(0.297)**	**(0.316)**	**(0.383)**	**(0.515)**
(b) gmm (lagged values)							
H excluding group	---	---	---	---	---	---	---
Dif(null, H=exogenous)	**(0.771)**	**(0.695)**	**(0.745)**	**(0.768)**	**(0.608)**	**(0.683)**	**(0.636)**
(c) IV (years, ICT, eq (diff))							
H excluding group	**(0.283)**	**(0.290)**	**(0.322)**	**(0.243)**	**(0.202)**	**(0.181)**	**(0.291)**
Dif(null, H=exogenous)	**(0.581)**	**(0.475)**	**(0.506)**	**(0.594)**	**(0.453)**	**(0.567)**	**(0.402)**
Fisher	**2417.83*** **	**8833.88*** **	**22941.49*** **	**4562.88*** **	**3514.78*** **	**11760.85*** **	**17126.81*** **
Instruments	39	39	39	39	39	39	39
Countries	42	42	42	42	42	42	42
Observations	456	456	457	456	456	456	455

Panel B: Atkinson

	Financial Depth		Financial Efficiency		Financial Activity		Fin. Size
	Money Supply M2	Liquid Liabilities Fdgdp	Banking sys. Efficiency BcBd	Financial sys. Efficiency FcFd	Banking sys. Activity Pcrob	Financial sys. Activity Pcrobof	Dbacba
Constant	**0.054** **	0.018	**-0.025***	-0.014	-0.020	-0.018	**0.045*** **
	(0.026)	(0.412)	**(0.068)**	(0.363)	(0.196)	(0.219)	**(0.004)**
Atkinson (-1)	**0.896*** **	**0.947*** **	**0.939*** **	**0.924*** **	**0.953*** **	**0.946*** **	**0.885*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Financial access	**-0.0002** **	**-0.0003*** **	**0.0001*** **	**0.012*** **	-0.00004	0.00002	**-0.0001** **
	(0.026)	**(0.004)**	**(0.007)**	**(0.001)**	(0.196)	(0.378)	**(0.016)**
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AR(1)	(0.048)	(0.043)	(0.055)	(0.046)	(0.062)	(0.064)	(0.056)
AR(2)	**(0.358)**	**(0.303)**	**(0.254)**	**(0.688)**	**(0.331)**	**(0.298)**	**(0.374)**
Sargan OIR	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.003)
Hansen OIR	**(0.506)**	**(0.312)**	**(0.227)**	**(0.136)**	**(0.250)**	**(0.278)**	**(0.220)**

DHT for instruments							
(a) GMM Instruments in levels							
H excluding group	**(0.370)**	**(0.246)**	**(0.396)**	**(0.324)**	**(0.354)**	**(0.348)**	**(0.372)**
Dif(null, H=exogenous)	**(0.591)**	**(0.450)**	**(0.182)**	**(0.115)**	**(0.238)**	**(0.281)**	**(0.187)**
(b) gmm (lagged values)							
H excluding group	---	---	---	---	---	---	---
Dif(null, H=exogenous)	**(0.735)**	**(0.523)**	**(0.415)**	**(0.272)**	**(0.412)**	**(0.449)**	**(0.369)**
(b) IV (years, ICT, eq (diff))							
H excluding group	**(0.143)**	(0.061)	**(0.147)**	**(0.242)**	(0.060)	(0.071)	(0.080)
Dif(null, H=exogenous)	**(0.767)**	**(0.699)**	**(0.380)**	**(0.165)**	**(0.601)**	**(0.615)**	**(0.488)**
Fisher	**3355.17*****	**2013.42*****	**4529.93*****	**2733.35*****	**1378.21*****	**2939.15*****	**1151.37*****
Instruments	39	39	39	39	39	39	39
Countries	42	42	42	42	42	42	42
Observations	456	456	457	456	456	456	455

Panel C: Palma ratio

	Financial Depth		Financial Efficiency		Financial Activity		Fin. Size
	Money Supply M2	Liquid Liabilities Fdgdp	Banking sys. Efficiency BcBd	Financial sys. Efficiency FcFd	Banking sys. Activity Pcrob	Financial sys. Activity Pcrobof	Dbacba
Constant	**0.758***	**0.888****	**-1.264*****	**-1.443*****	-0.354	-0.310	-0.643
	(0.073)	**(0.047)**	**(0.004)**	**(0.000)**	(0.270)	(0.283)	(0.139)
Palma ratio (-1)	**0.756*****	**0.773*****	**0.728*****	**0.709*****	**0.776*****	**0.775*****	**0.733*****
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Financial access	**-0.007*****	**-0.009*****	**0.007*****	**0.702*****	-0.0007	0.0001	-0.003
	(0.002)	**(0.001)**	**(0.004)**	**(0.005)**	(0.440)	(0.820)	(0.120)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AR(1)	(0.082)	(0.082)	(0.084)	(0.083)	(0.090)	(0.096)	(0.085)
AR(2)	**(0.275)**	**(0.276)**	**(0.282)**	**(0.290)**	**(0.303)**	**(0.295)**	**(0.269)**
Sargan OIR	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
Hansen OIR	**(0.668)**	**(0.521)**	**(0.343)**	**(0.303)**	**(0.401)**	**(0.408)**	**(0.263)**
DHT for instruments							
(a) GMM Instruments for levels							
H excluding group	**(0.539)**	**(0.554)**	**(0.143)**	**(0.255)**	**(0.472)**	**(0.429)**	**(0.290)**
Dif(null, H=exogenous)	**(0.647)**	**(0.422)**	**(0.702)**	**(0.422)**	**(0.337)**	**(0.385)**	**(0.315)**
(b) gmm (lagged values)							
H excluding group	---	---	---	---	---	---	---
Dif(null, H=exogenous)	**(0.900)**	**(0.803)**	**(0.638)**	**(0.592)**	**(0.683)**	**(0.697)**	**(0.551)**
(c) IV (years, ICT, eq (diff))							
H excluding group	**(0.280)**	**(0.268)**	**(0.126)**	**(0.182)**	**(0.186)**	**(0.223)**	**(0.156)**
Dif(null, H=exogenous)	**(0.799)**	**(0.645)**	**(0.591)**	**(0.451)**	**(0.582)**	**(0.549)**	**(0.425)**
Fisher	**472.15*****	**2222.57*****	**881.33*****	**978.49*****	**2489.98*****	**1761.29*****	**1549.93*****
Instruments	39	39	39	39	39	39	39
Countries	42	42	42	42	42	42	42
Observations	456	456	457	456	456	456	455

***,**,*: 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 Wald 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.

4.2. Extension with ICT-driven financial sector development and income inequality

Consistent with recent financial development literature (Tchamyou &Asongu, 2016; Asongu et al., 2017), we employ propositions which are presented in Table 6.For lack of space, the corresponding summary statistics and correlation matrix are available upon request. Panel A of Table 6 shows measures of financial sector development in relation to Gross Domestic

Product (GDP) while Panel B exhibits indicators related to competition for shares in money supply. The notion of financial sector development builds on the shares in money supply and is based on the concepts of informal, semi-formal, formal and non-formal financial sectors. For instance, an increase in the shares of the formal financial sector to the detriment of semi-formal and informal financial sectors is appreciated as financial formalization whereas the expansion of the informal financial sector at the expense of the semi-formal and formal financial sectors is qualified as financial informalization. In this perspective, the increase of the volume of money supply in circulation within a sector improves the underlying sector at the expense of other sectors (Tchamyou & Asongu, 2017). The notion of financial formalization should be distinguished from those of formal financial development and informal financial development which are contingent on shares in GDP within financial sectors. The computation of these propositions is based on the Financial Development and Structure Database (FDSD). Two financial sector development indicators are employed: Propositions 1 and 3for the formal financial sector and Propositions 5 and 7 for the informal financial sector development because: (i) Propositions 2 and 6 have issues of degrees of freedom while (ii) Propositions 3 and 7 are respectively highly correlated with Propositions 4 and 8.

Table 6: Summary of propositions

Propositions	Name(s)	Formula	Elucidation
Panel A: GDP-based financial development indicators			
Proposition 1	Formal financial development	Bank deposits/GDP	Bank deposits[5] here refer to demand, time and savings deposits in deposit money banks.
Proposition 2	Semi-formal financial development	(Financial deposits – Bank deposits)/ GDP	Financial deposits[6] are demand, time and saving deposits in deposit money banks and other financial institutions.
Proposition 3	Informal financial development	(Money Supply – Financial deposits)/GDP	
Proposition 4	Informal and semi-formal financial development	(Money Supply – Bank deposits)/GDP	
Panel B: Measures of financial sector importance			
Proposition 5	Financial intermediary formalization	Bank deposits/ Money Supply (M2)	From 'informal and semi-formal' to *formal* financial development (formalization)[7] .
Proposition 6	Financial intermediary 'semi-formalization'	(Financial deposits - Bank deposits)/ Money Supply	From 'informal and formal' to *semi-formal* financial development (Semi-formalization)[8].
Proposition 7	Financial intermediary 'informalization'	(Money Supply – Financial deposits)/ Money Supply	From 'formal and semi-formal' to *informal* financial development (Informalization)[9].
Proposition 8	Financial intermediary 'semi-formalization and informalization'	(Money Supply – Bank Deposits)/Money Supply	Formal to '*informal and semi-formal'* financial development: (Semi-formalization and informalization) [10]

N.B: Propositions 5, 6, 7 add up to unity (one) arithmetically spelling-out the underlying assumption of sector importance. Hence, when their time series properties are considered in empirical analysis, the evolution of one sector is to the detriment of other sectors and vice-versa.
Source: Asongu (2015b).

In the light of information criteria for the validity of models, the following findings are apparent from Table 7 on which the adopted propositions are employed as channels through which ICT affects inequality. In Panel A, while both formal financial sector development

[5] Lines 24 and 25 of the International Financial Statistics (October 2008).
[6] Lines 24, 25 and 45 of the International Financial Statistics (2008).
[7] "*Accordingly, in undeveloped countries money supply is not equal to liquid liabilities or bank deposits. While in undeveloped countries bank deposits as a ratio of money supply is less than one, in developed countries this ratio is almost equal to 1. This indicator appreciates the degree by which money in circulation is absorbed by the banking system. Here we define 'financial formalization' as the propensity of the formal banking system to absorb money in circulation.*" (Asongu, 2015b, p. 432).
[8] "*This indicator measures the rate at which the semi-formal financial sector is evolving at the expense of formal and informal sectors.*" (Asongu, 2015b, p. 432).
[9] "*This proposition appreciates the degree by which the informal financial sector is developing to the detriment of formal and semi-formal sectors.*" (Asongu, 2015b, p. 432).
[10] "*The proposition measures the deterioration of the formal banking sector in the interest of other financial sectors (informal and semi-formal). From common sense, propositions 5 and 8 should be almost perfectly antagonistic, meaning the former (formal financial development at the cost of other financial sectors) and the latter (formal sector deterioration) should almost display a perfectly negative degree of substitution or correlation.*" (Asongu, 2015b, p. 432).

(Proposition 1) and informal financial sector development (Proposition 3) reduce inequality, only financial sector formalization (Proposition 5) reduces inequality because financial sector informalization has a positive effect on inequality (Proposition 7). These findings supporting the relevance of the formal financial sector are overwhelmingly confirmed in Panel B and Panel C because the negative effect of informal financial sector development on inequality established in Panel A is now significantly positive and insignificantly positive in Panel B and Panel C respectively.

Table 7: ICT-driven financial sector development and Income Inequality

	Panel A: Gini Index							
	Proposition 1		Proposition 3		Proposition 5		Proposition 7	
Constant	**0.067*** **	**0.110*** **	**0.120*** **	**0.053*** **	**0.074*** **	**0.076*** **	**0.080*** **	**0.048*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Gini(-1)	**0.863*** **	**0.795*** **	**0.799*** **	**0.841*** **	**0.861*** **	**0.818*** **	**0.874*** **	**0.821*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Proposition 1	**-0.0001*** **	**-0.0002*** **	---	---	---	---	---	---
	(0.002)	**(0.000)**						
Proposition 3	---	---	**-0.0002***	0.00004	---	---	---	---
			(0.053)	(0.670)				
Proposition 5	---	---	---	---	-0.006	**-0.035*** **	---	---
					(0.417)	**(0.000)**		
Proposition 7	---	---	---	---	---	---	-0.005	**0.029*** **
							(0.578)	**(0.002)**
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	No	Yes	No	Yes	No	Yes	No	Yes
AR(1)	**(0.252)**	**(0.266)**	**(0.269)**	**(0.259)**	**(0.272)**	**(0.276)**	**(0.272)**	**(0.280)**
AR(2)	**(0.337)**	**(0.336)**	**(0.299)**	**(0.341)**	**(0.339)**	**(0.435)**	**(0.309)**	**(0.410)**
Sargan OIR	**(0.506)**	**(0.064)**	**(0.544)**	**(0.122)**	**(0.722)**	**(0.081)**	**(0.759)**	**(0.064)**
Hansen OIR	**(0.707)**	**(0.425)**	**(0.765)**	**(0.606)**	**(0.747)**	**(0.298)**	**(0.663)**	**(0.161)**
DHT for instruments								
(a) GMM Instruments for levels								
H excluding group	**(0.546)**	**(0.566)**	**(0.536)**	**(0.162)**	**(0.618)**	**(0.415)**	**(0.525)**	**(0.394)**
Dif(null, H=exogenous)	**(0.683)**	**(0.295)**	**(0.773)**	**(0.965)**	**(0.682)**	**(0.254)**	**(0.640)**	**(0.112)**
(b) gmm (lagged values)	---		---		---		---	
H excluding group		---		---		---		---
Dif(null, H=exogenous)		**(0.723)**		**(0.884)**		**(0.569)**		**(0.351)**
(c) IV (years, ICT, eq (diff))								
H excluding group	**(0.718)**	**(0.298)**	**(0.667)**	**(0.108)**	**(0.634)**	**(0.238)**	**(0.586)**	**(0.185)**
Dif(null, H=exogenous)	**(0.412)**	**(0.500)**	**(0.743)**	**(0.905)**	**(0.782)**	**(0.387)**	**(0.629)**	**(0.237)**
Fisher	**432.95*** **	**13632.34*** **	**370.72*** **	**966.88*** **	**951.98*** **	**6578.85*** **	**815.86*** **	**4243.79*** **
Instruments	26	39	26	39	26	39	26	39
Countries	42	42	44	44	42	42	42	42
Observations	456	456	474	474	456	456	456	456
	Panel B: Atkinson							
	Proposition 1		Proposition 3		Proposition 5		Proposition 7	
Constant	**-0.049** **	0.021	0.024	-0.011	-0.006	0.027	0.016	-0.000
	(0.034)	(0.365)	(0.204)	(0.548)	(0.741)	(0.140)	(0.495)	(0.977)
Atkinson (-1)	**1.030*** **	**0.944*** **	**0.925*** **	**0.917*** **	**0.964*** **	**0.912*** **	**0.951*** **	**0.906*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Financial access	-0.0001	**-0.0003*** **	0.00007	**0.0003***	0.011	**-0.037*** **	-0.004	**0.042** **
	(0.209)	**(0.003)**	(0.765)	**(0.061)**	(0.337)	**(0.002)**	(0.769)	**(0.011)**
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	No	Yes	No	Yes	No	Yes	No	Yes

AR(1)	(0.051)	(0.044)	(0.052)	(0.068)	(0.056)	(0.057)	(0.053)	(0.053)
AR(2)	(0.054)	**(0.294)**	**(0.596)**	**(0.358)**	**(0.208)**	**(0.219)**	**(0.270)**	**(0.297)**
Sargan OIR	(0.002)	(0.000)	(0.048)	(0.004)	(0.228)	(0.006)	(0.207)	(0.006)
Hansen OIR	**(0.560)**	**(0.332)**	(0.077)	**(0.331)**	**(0.218)**	**(0.240)**	**(0.173)**	**(0.257)**
DHT for instruments								
(a) GMM Instruments in levels								
H excluding group	**(0.318)**	**(0.235)**	**(0.303)**	(0.097)	**(0.468)**	**(0.289)**	**(0.619)**	**(0.457)**
Dif(null, H=exogenous)	**(0.700)**	**(0.502)**	**(0.064)**	**(0.806)**	**(0.148)**	**(0.280)**	(0.073)	**(0.181)**
(b) gmm (lagged values)	---		---		---		---	
H excluding group		---		---		---		---
Dif(null, H=exogenous)		**(0.545)**		**(0.507)**		**(0.389)**		**(0.435)**
(c) IV (years, ICT, eq (diff))								
H excluding group	**(0.415)**	(0.070)	**(0.166)**	(0.044)	**(0.252)**	(0.025)	**(0.250)**	(0.057)
Dif(null, H=exogenous)	**(0.829)**	**(0.700)**	(0.072)	**(0.786)**	**(0.247)**	**(0.758)**	**(0.154)**	**(0.626)**
Fisher	**388.56*****	**1833.79*****	**560.58*****	**640.55*****	**654.82*****	**1371.43*****	**531.94*****	**699.80*****
Instruments	26	39	26	39	26	39	26	39
Countries	42	42	44	44	42	42	42	42
Observations	456	456	474	474	456	456	456	456

Panel C: Palma ratio

	Proposition 1		Proposition 3		Proposition 5		Proposition 7	
Constant	0.714	**0.807***	**1.223****	**-0.870***	0.465	**-0.581***	**-1.458****	**-3.151*****
	(0.130)	**(0.073)**	**(0.012)**	**(0.086)**	(0.262)	**(0.081)**	**(0.014)**	**(0.000)**
Palma ratio (-1)	**0.664*****	**0.775*****	**0.635*****	**0.731*****	**0.680*****	**0.770*****	**0.730*****	**0.764*****
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Financial access	-0.0009	**-0.009*****	0.001	0.009	-0.563	**-1.150****	**1.439****	**3.054*****
	(0.749)	**(0.002)**	(0.911)	(0.137)	(0.203)	**(0.029)**	**(0.017)**	**(0.000)**
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	No	Yes	No	Yes	No	Yes	No	Yes
AR(1)	(0.067)	(0.083)	(0.089)	**(0.113)**	(0.083)	**(0.108)**	(0.094)	**(0.131)**
AR(2)	**(0.376)**	**(0.270)**	**(0.382)**	**(0.273)**	**(0.318)**	**(0.251)**	**(0.275)**	**(0.240)**
Sargan OIR	(0.000)	(0.000)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)
Hansen OIR	**(0.511)**	**(0.548)**	**(0.846)**	**(0.348)**	**(0.736)**	**(0.450)**	**(0.576)**	**(0.533)**
DHT for instruments								
(a) GMM Instruments for levels								
H excluding group	**(0.659)**	**(0.545)**	**(0.504)**	**(0.120)**	**(0.601)**	**(0.328)**	**(0.601)**	**(0.487)**
Dif(null, H=exogenous)	**(0.344)**	**(0.466)**	**(0.902)**	**(0.766)**	**(0.680)**	**(0.560)**	**(0.461)**	**(0.503)**
(b) gmm (lagged values)	---		---		---		---	
H excluding group		---		---		---		---
Dif(null, H=exogenous)		**(0.826)**		**(0.666)**		**(0.752)**		**(0.810)**
(c) IV (years, ICT, eq (diff))								
H excluding group	**(0.503)**	**(0.268)**	**(0.734)**	(0.087)	**(0.595)**	**(0.122)**	**(0.459)**	**(0.166)**
Dif(null, H=exogenous)	**(0.413)**	**(0.676)**	**(0.869)**	**(0.676)**	**(0.866)**	**(0.737)**	**(0.733)**	**(0.767)**
Fisher	**159.05*****	**1740.27*****	**163.97*****	**455.74*****	**262.27*****	**1300.43*****	**308.63*****	**446.42*****
Instruments	26	39	26	39	26	39	26	39
Countries	42	42	44	44	42	42	42	42
Observations	456	456	474	474	456	456	456	456

***,**,*: 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 Wald 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 following findings result from Table 7. First, formal financial development, informal financial development and financial intermediary formalization are negatively associated with the Gini index while informal intermediary formalization positively affects the underlying index. Results are broadly the same with the Atkinson measure, except for informal financial development. With regards to the Palma ratio, formal financial development and financial

intermediary formalization negatively affect the ratio while financial intermediary informalization has the opposite effect.

5. Concluding implications and future research directions

This study has investigated the role of ICT on income inequality through financial development dynamics of depth (money supply and liquid liabilities), efficiency (at banking and financial system levels), activity (from banking and financial system perspectives), in 48 African countries for the period 1996-2014. The empirical evidence is based on Generalised Method of Moments. Three main inequality dependent variables are used namely: the Gini index, the Palma ratio and the Atkinson index. Three ICT indicators are employed as strictly exogenous variables, namely: the internet penetration rate, the mobile penetration and fixed broad band subscription rate. While both financial depth and size are established to reduce inequality contingent on ICT, only the effect of financial depth in reducing inequality is robust to the inclusion of time invariant variables to the set of strictly exogenous variables. We extend the analysis by decomposing financial depth into its constituent components, namely, the: formal, informal, semi-formal and non-formal financial sectors. The findings based on this extension show that ICT reduces inequality through formal financial sector development and financial sector formalization as opposed to informal financial sector development and financial sector informalization. The study has contributed at the same time to macroeconomic literature on measuring financial development and responded to the growing field of addressing post-2015 SDGs inequality challenges by means of ICT and financial access.

Assuming ICT is substituted to information sharing offices (public credit registries and private credit bureaus), the financial sector related findings are broadly consistent with Asongu and Nwachukwu (2017b) who have concluded that the association of information sharing offices and financial formalization is a decreasing function of financial activity. However, the complementarity of financial formalization and information sharing offices is positive and represents an increasing function of credit access (or financial activity). It important to note that, the underlying study has focused on the complementarity between information sharing and financial sector development in financial access, by using quantile regressions to investigate relationships throughout the conditional distribution of financial access.

Consistent with the authors, we suggest measures that could be adopted by policy makers in order to reduce inequality through ICT for financial access. Before suggesting the policy measures, it is important to note that the positioning of this study is in line with the United Nations Sustainable Development Goals, notably: (i) Goal 10 (i.e. "*Reduce inequality within and among countries*") and (ii) Goal 17 (i.e."*Strengthen the means of implementation and revitalize the global partnership for sustainable development*"). Specific targets from the latter goal include: Target 17.3 (i.e."*mobilize financial resources for developing countries for multiple sources"* and Target 17.8 (i.e. "*fully operationalize the Technology Bank and STI (Science, Technology and Innovation) capacity building mechanism for LDCs by 2017, and enhance the use of enabling technologies in particular ICT"*) which are articulated around finance, technology and capacity building[11]. Hence, in what follows, the suggested policy measures centre on how established findings can be leveraged by policy makers to address Goals 10 and 17 in the light of fighting income inequality in the continent.

First, ICT services and mobile banking in particular, should be encouraged and tailored by regulators and governments such that they become accessible by end users, especially those previously excluded from formal banking establishments. The motivation for this is based on the fact that ICT enables customers to have access to information about their bank accounts and to store money. This is why the 2016 World Development Report advocated that the adoption of digitalization is not enough unless countries work towards "*analog complements*". Hence, complementing ICT with financial development in this study is worthwhile. As stated by Andrianaivo and Kpodar (2011), the development of mobile phones is consolidating the impact of financial inclusion on economic growth, particularly in countries where mobile financial services are taking root. In essence, while mobile banking is associated with real bank accounts in the formal financial sector, it is not the case with the informal financial sector which is not characterized by bank accounts. Moreover, in the formal financial sector, deposits are transformed into credit to ease and increase access to finance and hence, potentially reduce inequality.

Second, in a system where the informal financial sector is dominant, at least partial savings through ICT should be created to increase money circulation and therefore access to finance. In addition, this saving process has a twofold advantage: (i) it prevents potential theft

[11] More insights into the goals are apparent on the following link: https://www.un.org/sustainabledevelopment/sustainable-development-goals/

compared to saving at home, and (ii) it encourages better cash management by curbing impulse spending.

Third, shifting the method of payments from cash to ICT-related accounts has many possible advantages and in the long run can boost economic growth and productivity and therefore reduce inequality. For instance: (i) it might be particularly valuable for women empowerment, as they (i.e. women) can have greater discretion and control over their received payments (such as payments from government transfers; remittances and/or compensation from work). (ii) Paying bills regularly from cash to accounts (via mobile or telephone payments) can help individuals (and even companies) to build a data history of payments which could be used to facilitate access to credit. Credit histories are often viewed by lenders as an informative tool by which the ability of borrowers to meet their financial obligations can be assessed. (iii) Another interest of preferring bank account payments over cash payments is the increase in payment security and the reduction of potential incidences of crime. This is essentially because senders and recipients of huge amount of cash (for instance, rent payments, remittances or wages) are likely to face street crime. (iv) An additional benefit of using account payments rather than cash payments (both for senders and recipients) is the rapidity of the process, especially in case of long distance and more importantly in case of an emergency. For instance, a person residing in a rural area where there is no bank or money transfer operator must travel to send or receive money. However, there are some risks associated with travelling, such as: theft, street crime, among others.

Although we have obtained expected effects in the light of theoretical underpinnings, one could be concerned about the small magnitude of the estimated coefficients. This is the main caveat of the paper. However, we argue that applied econometrics should not exclusively be limited to accepting linkages based on estimated coefficients that are of very high magnitude. Small coefficients can as much have economic meaning and even lead to theory-building. Moreover, we set out to investigate some linkages and upon investigation we may be accused on the "file drawer problem" or publication bias if we prefer results with high magnitude and neglect findings of low magnitude.

Future research can improve extant literature by investigating the role of information sharing offices (such as public credit registries and private credit bureaus), in reducing inequality through underlying financial access mechanisms. The contribution of such an inquiry to existing literature will also provide insights into whether the established relationships in the

study withstand further empirical scrutiny. This is essentially because information sharing offices naturally employ ICT instruments.

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